AD-784 192

DEVELOPMENT AND EXPERIMENTAL VERIFICATION OF PROCEDURES TO DETERMINE NONLINEAR LOAD-DEFLECTION CHARACTERISTICS OF HELICOPTER SUBSTRUCTURES SUBJECTED TO CRASH FORCES. VOLUME II. TEST DATA AND DESCRIPTION OF REFINED PROGRAM 'KRASH', INCLUDING A USER'S GUIDE AND SAMPLE CASE

G. Wittlin, et al

Lockheed-California Company

Prepared for:

Army Air Mobility Research and Development Laboratory

May 1974

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER USAAMRDL-TR-74-12B	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER AD 784192
4. TITLE (and Subtitle) DEVELOPMENT AND EXPERIMENTAL VERIFICATION OF PROCEDURES TO DETERMINE NONLINEAR LOAD-DEFLECTION CHARACTERISTICS OF HELICOPTER STRUCTURES SUBJECTED TO CRASH FORCES - VOLUME II		5. TYPE OF REPORT & PERIOD COVERED Final report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) G. Wittlin K. C. Park		8. CONTRACT OR GRANT NUMBER(s) Contract DAAJ02-73-C-0051
9. PERFORMING ORGANIZATION NAME AND ADDRESS Lockheed-California Company Burbank, California 91503		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Task 1F162205AH88
11. CONTROLLING OFFICE NAME AND ADDRESS Eustis Directorate U. S. Army Air Mobility R&D Laboratory Fort Eustis, Virginia 23604		12. REPORT DATE May 1974 13. NUMBER OF PAGES 245
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Volume II of a two-volume report

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aircraft	Tolerances (physiology)
Crash resistance	Helicopters
Dynamics	Energy absorbers
Structural properties	Mathematical models

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The results of a study to develop simplified design procedures for determining nonlinear load-deflection characteristics for helicopter airframe structures ~~are presented~~. A literature survey is performed in which 60 technical reports and papers are evaluated with regard to their applicability to crashworthiness analysis and designer-oriented procedures.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

4. Continued.
TEST DATA AND DESCRIPTION OF REFINED PROGRAM "KRASH", INCLUDING A USER'S GUIDE AND SAMPLE CASE

20. Continued

Studies using an existing 31 lumped mass model of the UH-1H helicopter are performed to determine the sensitivity of responses to changes in the load-deflection representation for the engine and transmission mounts, landing gear and fuselage. Simplified techniques are used to predict the load-deflection curve for the crushing of a segment of the lower fuselage under impact conditions. The predictions include elastic behavior, failure load and post-failure behavior. The structural segment selected for analysis and test is a section supported on four edges, representative of the transmission pylon support.

Twelve specimens were fabricated. The specimens are 46 inches long by 18 inches wide by 6.125 inches to 12.125 inches deep. The 6.125-inch-deep specimens are approximately half the size (except for thickness) and are varied in detail design (number of angles, spacing of angles, lightening holes). Static and dynamic tests were performed. The predicted load-deflection curves are compared to the test load-deflection curves and show good agreement with regard to peak failure load, failure point, energy absorbed, and shape. The results of the tests show that for this type of typical fuselage structure, static tests provide load-deflection data which is similar to data that can be obtained from dynamic tests, but more economically.

Program KRASH is refined to facilitate its use by designers. In particular, the input data is reordered, some inputs are standardized and more general load-deflection curve characteristics are possible. The capacity of the program is increased to 80 lumped masses, 100 internal beams and 120 load-deflection tables. The refined program was run to demonstrate capability to treat a three-dimensional impact velocity, mass penetration into an occupiable space, and simplified rotor blade contact. Specimen test data is also used to refine the 31 mass UH-1H model.

The analytical techniques developed herein are presented in the form of design charts, nomographs, curves, tables and equations and form the basis of a structural crashworthiness design manual. The design procedures are outlined in a step-by-step process including examples.

Volume II contains supporting analytical and test data and a literature matrix categorization. A description of refined program KRASH is provided which shows the new input-output format, a listing, and sample problems.

EUSTIS DIRECTORATE POSITION STATEMENT

The Eustis Directorate technical monitor for this effort was Mr. G. T. Singley III of the Military Operations Technology Division.

The conclusions submitted by the contractor are considered to be valid.

The report is divided into two volumes. Volume I contains a description of the survey of technical publications, investigation of the sensitivity of the simulated structural response to load-deflection variations, substructure test program, refinement of KRASH, structural crashworthiness design procedures, and results obtained. Volume II contains abstracts of literature reviewed, supporting analytical and test data, a description of the refined KRASH computer program, and a user's guide for the computer program.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

INTRODUCTION

This volume contains test and analysis data in support of the detailed discussions presented in Volume I. The 60 technical reports and publications reviewed during the study are briefly summarized and then tabulated in a Literature Survey Subject Index. The test data is presented in the form of recorded load, deflection, strain and accelerometer readings versus scan (time). The refinements of program KRASH to facilitiate its usage are described. Included in the writeup for program KRASH is the refined input-output format, user's guide, listing, and two sample problems. Also included in the section on program KRASH are the energy balance equations and the sample format for the energy data.

LITERATURE SURVEY AND SYNOPSIS

1. Wittlin, G., Gamon, M.A., EXPERIMENTAL PROGRAM FOR THE DEVELOPMENT OF IMPROVED HELICOPTER STRUCTURAL CRASHWORTHINESS ANALYTICAL AND DESIGN TECHNIQUES, Lockheed-California Company; USAAMRDL Technical Report 72-72A,-72B, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, May 1973, AD 764985.

   This report presents the results of a four-phase study to develop improved rotary-wing aircraft structural crashworthiness analytical and design techniques. A digital computer program, designated KRASH, was developed and shown to be capable of accurately predicting responses during a crash in which multidirectional forces are present. The program was verified using controlled test data obtained on the same program via a combined vertical-lateral velocity impact using a fully instrumented UH-1H helicopter. Parameter studies were performed to ascertain the effect on the response of the structure and the occupants due to changes in structural element load deflection characteristics. A consistent design approach is presented, and the results of the parameter study are used to illustrate its application in a crash analysis. The study also included a detailed accident investigation, a literature survey and evaluation, substructure test, and analysis.

2. Turnbow, J.W., Carroll, D.F., Haley, J.L., Jr., Robertson, S.N., CRASH SURVIVAL DESIGN GUIDE, Dynamic Science; USAAMRDL Technical Report 71-22, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, October 1971, AD 733358.

   This report is a design guide that has been assembled to provide the engineer with an understanding of the basic problems associated with the development of crashworthy U.S. Army aircraft. Where possible, solutions to specific problems are indicated. In areas in which little design data are available, only the general philosophy appropriate to the problem solution is presented; the details of such solutions as well as the degree of crashworthiness to be achieved must be left, at present, to the ingenuity of the designer.

   This guide presents, in a condensed form, the data, design techniques, and criteria that are presently available in eight areas: (1) aircraft crash kinematic and survival envelope, (2) airframe crashworthiness design criteria, (3) aircraft seat design criteria (crew and troop/passenger), (4) restraint system design criteria (crew, troop/passenger, and cargo), (5) occupant environment design criteria, (6) aircraft ancillary equipment stowage design criteria, (7) emergency escape provisions, and (8) postcrash fire design criteria.

   It is intended that both airframe and component designers and manufacturers use this guide to extend the "region of survivability" in aircraft accidents to a maximum level.

3. Reed, William H., Avery, James P., Ph.D, PRINCIPLES FOR IMPROVING STRUCTURAL CRASHWORTHINESS FOR STOL AND CTOL AIRCRAFT, Aviation Safety Engineering and Research; USAAVLABS Technical Report 66-39, U.S. Army Aviation Materiel Laboratories, Fort Eustis, Virginia, June 1966, AD 637133.

In this report the crash behavior of aircraft structures is investigated. The investigation begins with the definition of two indices of crashworthiness of basic aircraft structures and the analysis of the influence of several general types of structural modifications upon these two indices. This analysis, using fundamental principles of mechanics, contains several simplifying assumptions, which are explained as they are introduced.

Design concepts to improve the ability of the "protective container" to maintain living space for occupants during a crash or to attenuate the accelerations experienced by occupants during a crash are developed for crash conditions which are either primarily longitudinal in nature or primarily vertical in nature. Analytical methods are then provided to show how and when to apply these design concepts to any particular aircraft. Principles are presented which are considered to be suitable for use during design of new aircraft as well as modifications of existing aircraft.

The results are presented from three full-scale crash tests of small twin-engine airplanes which were conducted as a part of this investigation.

Among the pertinent conclusions of the report are: (1) improvements in crashworthiness can be achieved via minor changes in structural design or modification of existing structure, (2) vertical and longitudinal impact environments offer significantly different problems in designing for improved crashworthiness, and (3) analysis of aircraft behavior is hampered by the lack of adequate knowledge of the relationships which apply to the determination of the reaction force which decelerates the aircraft upon contact with the ground.

4. Greer, D.L., et al, DESIGN STUDY AND MODEL STRUCTURES TEST PROGRAM TO IMPROVE FUSELAGE CRASHWORTHINESS, General Dynamics, Convair; FAA Report DS-67-20, Federal Aviation Administration, Washington, D.C., October 1967, AD 666816.

This report presents the results of a study to evaluate methods to improve crashworthiness by retaining transport cabin integrity during crash impact loadings.

The study includes analyses of the effects of strengthening, redistribution of bending material, and incorporation of energy dissipating features on the ability of the fuselage to provide a protective shell

around the occupants. Analytical results were substantiated by a test program.

The test program included compression tests of plate-stringer panels and drop tests of representative fuselage structure. Tests were made on three 100-inch-diameter cylindrical sections dropped axially, four segments of 100-inch-diameter cylinders dropped laterally, and a structurally comple' nose section of a jet transport dropped in a 10-degree nose-down attitude.

The requirement for a plastically deforming structure is important for both axial and vertical collapse characteristics of a fuselage. Plastic collapse provides the most efficient energy-absorbing capability and also reduces the possibility of excessive tearing or complete disintegration of the structure.

Both energy-absorbing capacity and failure mode are important for vertical crushing conditions. The recommended manner of reinforcement for the fuselage lower frame segments strengthens the bottom centerline portion and the floor beam to frame area. No significant weight or cost penalty is involved since the crash requirement reinforcement occurs at the most critical areas for existing design conditions.

5. Saczalski, K.J., and Park, K.C., TRANSIENT RESPONSE OF INELASTICALLY CONSTRAINED RIGID BODY SYSTEMS, to appear in the Journal of Engineering for Industry, A.S.M.E. Transactions, 1974.

An energy rate balance is employed to develop the incremental equations of motion for a shock-loaded, inelastically constrained, rigid-body structural system. Lagrangian multipliers provide the coupling mechanism necessary to reduce the overall system of equations to a set of modified rigid-body equations which include the nonlinear geometric and structural material effects. Kinematic material hardening and a modified yield criteria are used. Examples illustrate the technique and are compared with experimental results.

6. Massonnet, C.E., and Save, M.A., PLASTIC ANALYSIS AND DESIGN, VOL. I, BEAMS AND FRAMES; Blusdell, New York, 1965.

This book deals with the analysis and design of beams and frames made of a ductile material on the basis of the ultimate load. With the second volume, which is concerned with more complicated structures such as plates and shells, it aims at giving a broad (if not exhaustive) coverage of plastic analysis and design methods. These methods essentially apply to mild steel structures, but may also be used, with adequate caution, for reinforced and prestressed concrete structures.

Presently, the first volume is the most important for practical applications. The so-called simple plastic theory of beams and frames is

presented in Volume II, which is now being finalized.

The material has been considered as an engineering problem and not as applied mathematics. Much attention and extensive treatment have been given to plastic buckling and to design of joints. The influence of details of construction (machining, drilling, punching, etc.) is also considered.

7. Roark, R.J., FORMULAS FOR STRESS AND STRAIN, McGraw-Hill, New York, 1965.

This book provides a compact, complete summary of the formulas, facts, and principles pertaining to strength of materials. It is intended primarily as a reference book and represents an attempt to meet what is believed to be a present need of the design engineer.

Presented are certain general principles. Included are brief descriptions of analytical and experimental methods of stress analysis and information concerning the behavior of material under stress. The behavior of structural elements under various conditions of loading is discussed, and extensive tables of formulas for the calculation of stress, strain, and strength are given. Derivations and detailed explanations are omitted. However, examples are included to illustrate the application of the various formulas and methods.

8. Ayre, Robert S., Shock and Vibration Handbook, Chap. 8, Vol. 1, TRANSIENT RESPONSE TO STEP AND PULSE FUNCTIONS, McGraw-Hill, 1961.

Hoppmann, W.K., Shock and Vibration Handbook, Chap. 9, Vol. 1, EFFECTS OF IMPACT ON STRUCTURES, McGraw-Hill, New York, 1961.

Chapter 8 deals briefly with methods of analysis for obtaining the response spectrum from the time history, and includes in graphical form certain significant spectra for various regular step- and pulse-type excitations. The usual concept of the response spectrum is based upon the single-degree-of-freedom system, usually considered linear and undamped although useful information sometimes can be obtained by introducing nonlinearity or damping. The single-degree-of-freedom system is considered to be subjected to the shock or transient vibration, and its response is determined.

The response spectrum is a graphical presentation of a reflected quantity in the response taken with reference to a quantity in the excitation. It is plotted as a function of a dimensionless parameter that includes the natural period of the responding system and a significant period of the excitation. The excitation may be defined in terms of various physical quantities, and the response spectrum likewise may depict various characteristics of the response.

Chapter 9 discusses a particular phenomenon in the general field of shock and vibration usually referred to as impact. An impact occurs when two or more bodies collide. An important characteristic of an impact is the generation of relatively large forces at points of contact for relatively short periods of time. Such forces sometimes are referred to as impulse-type forces.

Three general classes of impact are considered in this chapter: (1) impact between spheres or other rigid bodies, where a body is considered to be rigid if its dimensions are large relative to the wavelengths of the elastic stress waves in the body; (2) impact of a rigid body against a beam or plate that remains substantially elastic during the impact; and (3) impact involving yielding of structures.

9. Timoshenko, S. Woinowsky-Krieger, S., THEORY OF PLATES AND SHELLS, McGraw-Hill Publishers, New York, 1959.

This book deals with the three regions of plate and shell theory: (1) thin plates with small deflections; (2) thin plates with large deflections; (3) thick plates. The book considers problems with membrane stresses and the case with clamped edges. Simplifications are given for special cases of deformation to the shape of a developable surface. The thick plate theory presented considers the problem as a three-dimensional problem of elasticity.

10. Tulk, F.D., BUCKLING OF CIRCULAR CYLINDRICAL SHELLS UNDER DYNAMICALLY APPLIED AXIAL LOADS, UTIAS report 160, 1972.

A theoretical and experimental study was made of the buckling characteristics of perfect and imperfect circular cylindrical shells subjected to dynamic axial loading.

The tests were performed on a specially designed dynamic testing machine which was capable of producing controlled ramp-type loads at rates ranging from the quasi-static up to higher than 200,000 pounds/second. Ten shell specimens were tested, including two near-perfect shells, seven shells with axisymmetric sinusoidal imperfections of a variety of amplitudes and wavelengths, and one shell with quasi-random axisymmetric imperfections. The shells were produced from a photoelastic epoxy plastic using a spin-casting technique. The imperfection profiles were machined into the shell walls using a high-precision hydraulic tracing apparatus. For three of the shells with sinusoidal imperfections, imperfection profiles were cut on the inner surface alone; while for the remaining four shells with sinusoidal imperfections and for the shell with quasi-random imperfections, a special manufacturing procedure was adopted which produced shells with matching inner and outer profiles, thus providing effectively constant thickness walls.

Experimental data included dynamic buckling loads (124 data points), high-speed photographs of the buckling mode shapes, and observations of the dynamic stability of shells subjected to rapidly applied subcritical loads.

A mathematical model is developed to describe the dynamic behavior of perfect and imperfect shells. This model is based on the Donnell-von Karman compatibility and equilibrium equations and has a wall deflection function incorporating five separate modes of deflection. Close agreement between theory and experiment is found for both dynamic buckling strength and buckling mode shapes.

11. Stricklin, J.E., et al, LARGE DEFLECTION ELASTIC-PLASTIC DYNAMIC RESPONSE OF STIFFENED SHELLS OF REVOLUTION, TEES-RPT-72-25 and SLA-73-0128, 1972.

This report presents the formulation and check-out problems for a computer code DYNAPLAS, which analyzes the large deflection elastic-plastic dynamic response of stiffened shells of revolution. The formulation is by the finite element method, with finite differences being used for the evaluation of the pseudo forces due to material and geometric nonlinearities. Time integration is by the Houbolt method. The stiffness may be due to concentrated or distributed eccentric rings and spring supports at arbitrary angles around the circumference of the elements. Check-out problems include the comparison of solutions from DYNAPLAS with experimental and other computer calculations for rings, conical and cylindrical shells, and a curved panel. A hypothetical submarine including stiffeners and missile tube is studied under a combination of hydrostatic and dynamically applied asymmetrical pressure loadings.

12. Becker, H., and Gerard G., HANDBOOKS OF STRUCTURAL STABILITY, PARTS I-V, NACA Technical Notes 3781-3785, 1957.

The local buckling of stiffener sections and the buckling of plates with angle stiffeners are reviewed, and the results are summarized in charts and tables. Numerical values of buckling coefficients are presented for longitudinally compressed stiffener sections of various shapes, and for stiffened cylinders loaded in torsion. Although the data presented consists primarily of elastic-buckling coefficients, the effects of plasticity are discussed for a few special cases.

13. Skogh, J., Stern, P., POSTBUCKLING BEHAVIOR OF A SECTION REPRESENTATIVE OF THE B-1 AFT INTERMEDIATE FUSELAGE, Lockheed Palto Alto Research Laboratory, AFFDL-TR-73-63, Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, May 1973.

A section of the B-1 aft intermediate fuselage consisting of a combination of flat and curved panels is analyzed for postbuckling strength under a combination of torque and axial loading. The analysis, which extends to load levels about ten times the load that produces the first buckle, was carried out rigorously by the use of the finite-difference computer code STAGS. The results show that the fuselage section does not collapse at the applied ultimate load. Shear stiffness values as a function of the applied load are calculated. These data can be used as inputs for a finite-element analysis of the fuselage section.

14. Atluri, S., PETROS 3: A FINITE-DIFFERENCE METHOD AND PROGRAM FOR THE CALCULATION OF LARGE ELASTIC-PLASTIC DYNAMICALLY-INDUCED DEFORMATIONS OF MULTILAYER VARIABLE THICKNESS SHELLS, BRL, U.S. Army Aberdeen Research & Development Center, Aberdeen Proving Ground, Maryland, Contract #DAAD05-68-C-0314, Nov. 1971.

The governing equations for the arbitrarily large-deformation elastic-plastic transient responses of variable-thickness, hard-bonded, multilayer, multimaterial, thin, Kirchhoff shells of any initial shape are formulated and solved by the finite-difference technique. The material is assumed to be initially isotropic and to exhibit elastic, strain-hardening, strain-rate-sensitive, and temperature-dependent behavior. The structure may be subjected to a variety of initial velocity distributions, transient mechanical loads, and/or transient thermal loads. These capabilities and features are contained in a computer program, PETROS 3, which has been applied to a variety of example problems.

Included is a FORTRAN IV listing and a description of PETROS 3 together with the data input and solution output for several example problems.

15. Haftka, R.T., A KOITER-TYPE METHOD FOR FINITE ELEMENT ANALYSIS OF NONLINEAR STRUCTURAL BEHAVIOR, AFFDL-TR-70-130, Vol. I, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, Nov. 1970.

Koiter's method for the asymptotic analysis of post-buckling behavior is reformulated in finite element notation for application to structures idealized by finite element models. Originally restricted to the analysis either of structures exhibiting bifurcation buckling or of slightly imperfect versions of such structures, Koiter's method is therein adapted to a more general class of structures exhibiting the more common snap-through (limit point) type of buckling. This adaption of Koiter's method is referred to as the Modified Structure method. It is accomplished by modification of the actual energy functional to create a hypothetical modified structure having a strictly linear pre-buckling path along which buckling must be of

the bifurcation type. The analysis of the actual structure is then accomplished by application of Koiter's method through consideration of the actual structure as an imperfect version of the modified structure.

In this way, the Modified Structure method operates within the theoretical framework established by Koiter, and the effects of prebuckling nonlinearity are approximated asymptotically. Various levels of approximation are considered. Additionally, the use of the Modified Structure method, in conjunction with direct methods of nonlinear analysis, is examined. A highly accurate finite element representation is employed in presenting a comprehensive numerical evaluation of the Modified Structure method of analysis on the basis of a number of planar frame problems. Collectively, these examples exhibit a broad spectrum of nonlinear behavior characteristics. Emphasis throughout is placed upon assessing the limitations and attributes of the Modified Structure method of analysis. Conclusions regarding applicability and performance emerge from detailed examination of the results obtained.

16. Stilwell, W.C., and Ball, R.E., A DIGITAL COMPUTER STUDY OF THE BUCKLING OF SHALLOW SPHERICAL CAPS AND TRUNCATED HEMISPHERES, NASA CR 1998, June 1972.

Several user-oriented digital computer programs for the static analysis of shells of revolution exist. A detailed discussion of most of these programs is given in Reference 1 of the report. Of particular interest here is the program developed by Ball (Reference 2) for the geometrically nonlinear analysis of arbitrarily loaded shells of revolution. This program is an equilibrium program; that is, it solves for the displacement and stress resultant fields for an arbitrary loading condition. Since geometric nonlinearities are included, the magnitude of load that leads to a condition of instability can be determined.

The utility of the program would be considerably enhanced if it could be used to determine bifurcation buckling loads and the behavior of the shell in the vicinity of the bifurcation load. This latter feature is often referred to as the imperfection sensitivity of the shell to the load. As a consequence, the objective of this study was to use the computer program to examine the buckling behavior of several shells subjected to axisymmetric and nearly axisymmetric loads. It was anticipated that an examination of the effects of the small asymmetric perturbations upon the stability of the shell would disclose the bifurcation buckling load and provide a quantitative evaluation of the imperfection sensitivity of the shell to the load.

17. Witmer, E.A., LARGE DYNAMIC DEFORMATIONS OF BEAMS, RINGS, PLATES AND SHELLS, AIAA Journal, Vol. I, No. 2, August 1963.

The axisymmetric responses of shells, plates, rings, and beams to impulsive or blast loading that produces large deformations involving both the elastic and plastic regions of material behavior are analyzed. A general numerical method that includes (1) elastic, (2) perfectly plastic, (3) elastic, strain-hardening, and/or (4) elastic, strain-hardening, strain-rate sensitive material behavior and large structural deflections is formulated and applied. In the timewise step-by-step numerical analysis, the increments in stress resultants and stress couples are determined by idealizing the shell thickness as consisting of n concentrated layers of materials separated by a material that cannot carry normal stresses but has infinite shear rigidity. The influences of the number of layers employed in the idealized model, as well as the aforementioned various types of material behavior, are demonstrated. Theoretical predictions of time-history responses and/or final structural deformations are compared with experimental data for impact-loaded spherical shells, for blast-loaded circular plates, and for explosively loaded circular rings and clamped beams.

18. Perrone, N., ON A SIMPLIFIED METHOD FOR SOLVING IMPULSIVELY LOADED STRUCTURES OF RATE-SENSITIVE MATERIALS, Office of Naval Research, Washington, D.C., Journal of Applied Mechanics, A.S.M.E., September 1965.

In an attempt to assess more completely rate-sensitivie material effects, two fundamental structural elements are analyzed: a wire with an impulsively loaded end mass, and an impulsively loaded ring. The ring and wire are made of perfectly plastic, rate-sensitive materials. In each case, exact and approximate solutions are obtained for an exponential rate-sensitivity law. The results suggest that very good approximations to the exact solutions may be found by utilizing a rate-insensitive material with constant yield stress equal to the initial dynamic yield stress.

19. Bodner, S.R., and Symonds, P.S., EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE PLASTIC DEFORMATION OF CANTILEVER BEAMS SUBJECTED TO IMPULSIVE LOADING, Brown University, Journal of Applied Mechanics, December 1962.

The experimental techniques and the results obtained in a program to evaluate the assumptions of dynamic, rigid-plastic theory of beams are presented. The experiments use steel and aluminum-alloy cantilever beams subjected to either a rapid velocity change at the base or to an impulsive load at the tip. A rigid-plastic theory that includes the strain-rate dependence of the yield stress and geometry changes is outlined for the case of the tip impulsive loading. Predictions of this theory are in satisfactory agreement with the experimental results.

20. Hibbit, H.D., et al, A FINITE ELEMENT FORUMLATION FOR PROBLEMS OF LARGE STRAIN AND LARGE DISPLACEMENT, Brown University, Int'l Journal of Solids and Structures, 1970, Vol 6, pp. 1069-1086.

An incremental and piecewise linear finite element theory is developed for the large-displacement, large-strain regime with particular reference to elastic-plastic behavior in metals. The resulting equations, though more complex, are in a similar form to those previously developed for large-displacement, small-strain problems, the only additional term being an initial load stiffness matrix which is dependent on current loads. This similarity in form means that existing nonlinear general-purpose programs may easily be extended to include finite strains. A large-displacement, small-strain formulation (as applicable to problems of structural stability) is obtained from this theory by assuming that changes in length of line elements and relative rotation of orthogonal line elements are negligible compared to unity. The simplified equations are in essential agreement with previous formulations in the literature. The only difference which is observed is the persistence of the initial load stiffness matrix, which may be significant in some cases.

21. Toridio, T.G., and Khozeimeh, K., INELASTIC RESPONSE OF FRAMES TO DYNAMIC LOADS, Journal of Engineering Mechanics, June 1971.

A procedure of analysis is presented for determining the elastic-inelastic response of framed structures under dynamic loads. Application of Hamilton's principle in conjunction with the finite-element method leads to the basic dynamic equation of the system incorporating the plastic effects in the form of equivalent nodal forces. This approach also allows the more accurate treatment of the distributed mass of the element than the usual geometrical method of lumping.

22. McDaniel, T.J., DYNAMICS OF STIFFENED CYLINDRICAL SHELLS WITH SPATIALLY VARYING CURVATURE, University of Dayton Research Institute, Air Force Materials Laboratory Report AFML-TR-72-134, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, July 1972.

This report presents the results of a theoretical study of the effects of spatially varying curvature on the dynamics of cylindrical panels and stiffened cylindrical shell structures. The first section of the report contains a brief discussion of the general problem area. Following this discussion, the analytical techniques for solving constant-curvature cylindrical panels and stiffened cylindrical shell problems by a transfer matrix approach are reviewed. These techniques are found to apply directly to the varying curvature shell analysis, provided the transfer matrix for this type of shell can be obtained. An analytical approach to obtaining the transfer matrix for a shell with varying curvature is explored. A solution to the transfer matrix for a cylindrical shell with exponentially varying curvature is obtained. In a following section, the preparation of this solution to obtain numerical transfer matrix is discussed. Several approximate and numerical

procedures for obtaining a transfer matrix are explored. Finally, the dynamic responses of both single panels and stringer stiffened cylindrical structures with increasing and decreasing curvature are compared to similar structures with constant curvature.

23. Bendix Corp., Final Engineering Report, ENERGY ABSORBING CHARACTERISTICS OF CRUSHABLE ALUMINUM STRUCTURES IN A SPACE ENVIRONMENT, NASA-CR-65096, July 1965.

The research effort detailed in this report involves the basic objective of obtaining quantitative design data concerning the characteristics of aluminum honeycomb materials when used in high L/D ratio, crushable, energy-absorbing capsules. Nine configurations of honeycomb energy-absorbing capsules using alloy 5056 are evaluated. The nine basic configurations incorporate three cross-sectional shapes of high, medium, and low crush strength, each of which was fabricated with cell axes oriented at angles of 0, 15 and 30 degrees to the capsule longitudinal axis. The characteristics which are studied included specific energy, load onset rate, and rebound. Variations of these characteristics are investigated under controlled environmental conditions.

The capsules were subjected to both static and dynamic loads, impact velocities from 5 thru 20 feet per second, and impact weights varying from 760 thru 3750 pounds. The environmental extremes under which the specimens were tested spanned the temperature range from -260°F thru room temperature up to +300°F, and a vacuum of 3×10^{-1} TORR.

24. Kornhauser, M., STRUCTURAL EFFECTS OF IMPACT, Sparton Books, Inc., Baltimore, Md., 1964.

Mechanical impact has been treated traditionally, in the United States, as a subject which is variously appended to college textbooks on elasticity, strength of materials, engineering mechanics, or vibrations. The elasticity and strength of materials texts are generally concerned with local surface effects or with stress waves; the mechanics texts usually treat the whole-body motions on impact; and the vibrations texts are apt to consider impact a special case of unsteady vibrations and amplification factors. In the actual case of impact, all of these phenomena and effects come into play, and the significance of each effect must be emphasized relative to the purpose of the analysis.

In this book the emphasis is placed on go or no-go behavior, survivability, or failure. Loading and response must, or course, be analyzed. Nevertheless, wherever possible, the object is to permit estimates of failure directly in terms of the loading conditions. Impact is a complex process. Given the loading history of a structure (and assuming no interaction with the structure's response), it is, in general, impossible to trace the stress waves and their

reflections throughout the structure, resulting in vibrations and permanent set or failure. Many solutions of loading and response, as well as theories of failure in terms of material properties, are available in the literature for various idealized conditions and configurations. What is desired by the practicing engineer are some relatively simple approaches to prediction of failure. This book is intended as a start in this direction.

In attempting to provide engineering answers to some very complex problems, liberal use has neen made of "engineering judgment" and idealizations. The soundness of each assumption is in proportion to the number of exact theoretical and experimental results available for very similar situations. For this reason it is anticipated that modifications of the approaches presented therein will be appropriate as the various disciplines produce more data.

The book is organized in three sections: "Loading Conditions", "Response and Failure of Structures", and "Effects of Impact." The section on response and failure is expository in nature, introducing the background theory and application of the sensitivity method of presenting and predicting inertial failure, as well as discussing low-speed and hypervelocity impact effects. Having accepted the approaches recommended in the second section, the practicing engineer may use the curves and tables of the first and third sections for prediction of impact effects in terms of the environmental input functions.

25. Fisher, L. J., Jr., LANDING-IMPACT-DISSIPATION SYSTEMS, NASA, Technical Note D-975, December 1961.

Analytical and experimental investigations are made to determine the landing-energy-dissipation characteristics for several types of earth-landing-impact systems having application to reentry vehicles. The areas of study are divided into three velocity regions: (1) those having primarily vertical velocity, (2) those having both moderate horizontal and moderate vertical velocity, and (3) those having primarily horizontal velocity. The impact systems discussed are braking rockets, gas-filled bags, frangible metal tubing, aluminum honeycomb, balsa wood, strain straps, and both skid and skid-rocker landings on hard-surface runways and on water.

The report states that it appears feasible to evaluate landing-gear systems for reentry vehicles by computational methods and free-body landing techniques with energy dissipation for an earth landing of such a vehicle. Some systems are more efficient than others, some package better than others, and a variety of promising systems are under study. Horizontal energy dissipation is simpler to deal with than vertical energy dissipation since translational friction is all that is involved; however, runout behavior becomes a factor. Vertical velocity can also be a big factor when high flight-path angles are

associated with even moderate horizontal velocities. High-speed landings are particularly a problem, especially high-speed water landings, and indications are that if large horizontal velocities are involved in hard-surface landings, a selected site will be required.

26. McGehee, J. R., A PRELIMINARY EXPERIMENTAL INVESTIGATION OF AN ENERGY-ABSORPTION PROCESS EMPLOYING FRANGIBLE METAL TUBING, NASA Technical Note D-1477, 1962.

A highly efficient energy-absorption process, employing frangible metal tubing as the working element, is investigated. A preliminary experimental investigation is conducted to determine the variation of the average fragmenting stress of 2024-T3 aluminum-alloy tubing with the pertinent parameters of this process. Limited tests were made to determine the feasibility of employing this process in a landing-gear system. A 1/5-scale model of a proposed manned spacecraft with a landing gear incorporating this process is employed in these tests.

The results of this investigation show that the fragmenting process produces a fluctuating force with displacement, but for a fixed set of parameters, the force about which the fluctuation occurs is approximately constant. A large force which occurs when the process is started with the unaltered tube seated symmetrically in the die can be reduced most effectively by tapering the wall thickness over a short length at the die end of the tube. The average fragmenting stress, for 2024-T3 aluminum-alloy tubing and the range of parameters investigated, appears to be independent of the ratio of wall thickness to tube diameter, but varies as the cube of the ratio of the wall thickness to the radius of the forming die. The fragmenting stress obtained at 12,000 inches per minute was about 60 percent higher than those obtained at 1 inch per minute. The 2024-T3 aluminum-alloy tubing, when fragmenting on a die at 90 percent of the yield stress, is capable of absorbing 31,000 foot-pounds of energy per pound of material. This energy-absorption capability is greater than that of the most frequently considered processes; for example, the crushing of balsa wood, aluminum honeycomb, or pressurized thin-walled metallic cylinders. Model tests, employing frangible tubing as the working element in the landing gear, indicate that this process is suitable for use in a load-alleviation application.

27. Kroell, C. K., A SIMPLE, EFFICIENT, ONE SHOT ENERGY ABSORBER, General Motors Research Laboratory, Warren, Michigan, Shock, Vibration and Associated Environments, Part III, Bulletin No. 30, 1962.

This paper describes a single-shot expendable energy absorber which has been developed at the General Motors Research Laboratory. The device is inherently simple and is characterized by a rectangular force-displacement relationship and high specific energy absorption capacity. Both a qualitative discussion of the mechanics of the

plastic deformation process involved and a graphical summary of the experimental performance data which have been collected to date are presented.

28. Weinberg, L.W.T., and Turnbow, J.W., Ph.D., SURVIVABILITY SEAT DESIGN DYNAMIC TEST PROGRAM, Aviation Safety Engineering and Research, USAAVLABS Technical Report 65-43, U.S. Army Aviation Materiel Laboratories, Fort Eustis, Virginia, July 1965, AD 621718.

This report presents the results of a series of dynamic tests conducted with four different concepts of experimental crew seats.

The experimental seats were designed and constructed by four helicopter manufacturers. The seats were designed to withstand static load factors equivalent to those recommended in TRECOM Technical Report 63-4, "Crew Seat Design Criteria for Army Aircraft", dated February 1963.

The design load factors recommended in the above-referenced report are as follows: longitudinal - 45G for 0.10 second; lateral - 45G for 0.10 second; and vertical - 25G for 0.10 second.

Special kits for small-arms ballistic protection were also designed and installed in the seats tested.

These seats were designed exclusively using static load factors. No previous testing was conducted by any seat manufacturer prior to the conduct of these tests.

The four seats were tested under four load conditions. Two of the conditions involved simultaneous half loads on the seats in two different seat positions, and two of the conditions involved full loads in two different seat positions.

Only one of the four seats tested withstood the loads imposed for all four conditions. Three of the seats failed and were damaged beyond economical repair when each was subjected to the first full-load test condition.

This report also includes a detailed description of an acceleration device which was specifically designed and fabricated for this series of tests.

29. Langhaar, H. L., THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THIN-WEBBED PLATE-GIRDER BEAMS, Transactions of the ASME, October 1943.

A simple, semirational theory for the design of webs and flange rivets of thin-webbed rectangular plate-girder shear beams is presented. Calculations of shear loads to cause web rupture and flange rivet failure are compared with test data from 27 beams.

30. Perry, D. J., AIRCRAFT STRUCTURES, McGraw Hill Book Co., New York, 1950.

In this book an attempt is made to emphasize basic structural theory which will not change as new materials and new construction methods are developed. Most of the theory is applicable for any design requirements and for any materials. The design engineer may then supplement this theory with the detail design specifications and the material properties which are applicable to his particular airplane.

Heavy emphasis is placed on the application of the elementary principles of mechanics to the analysis of aircraft structures.

31. Jones, N., et al, THE DYNAMIC PLASTIC BEHAVIOR OF SHELLS, MIT Report 71-6, 1971.

A survey is made of the literature published previously on the inelastic behavior of shells subjected to dynamic loads. An experimental investigation is also being undertaken to examine the behavior of various cylindrical shell panels which are loaded with an impulse on the inner surface. The panels are fully clamped along the two longitudinal edges and free on the other two. The initial kinetic energy of the dynamic loads is sufficiently large to cause inelastic behavior and to produce maximum permanent transverse deflections of up to nearly twice the corresponding panel thickness. Tests are conducted on mild steel and aluminum 6061-T6 panels which have various thicknesses and included angle of 90° approximately.

32. Mitchell, B., THE DYNASORB ENERGY ABSORBER, Lockheed Report LR 16735, March 1963.

This report introduces a method of absorbing energy while maintaining a constant load level. The tubular load-carrying member can support its full load capability and still be almost totally consumed by rolling up one end. The energy curves presented are typical and show excellent load consistency with efficiencies as high as 450,000 in.-lb/lb.

33. Mitchell, B., SHOCK ABSORPTION WITH ONE SLOT TUBES, Lockheed Report LR 16369, June 1963.

The work covered in this report is a follow-on of an independent research program that developed a very efficient method of absorbing energy by load control and end roll-up of tubes. This study investigates 12 different materials and improves the control rings to give a smooth, nearly rectangular, energy curve. The load level can be set, by suitable design, at any desired point within the column or local

strength limits of the tube. The maximum efficiency attained here with a 2-inch-diameter by .049 wall 4130 steel tube heat treated to 200,000 psi is 600,000 in.-lb per lb of tube weight. This represents a mean compressive stress of 189,000 psi over the total 6 inches of travel.

34. Mitchell, B., DESIGN NOTES FOR THE DYNASORB ENERGY ABSORBER, Lockheed Report LR 17201, December 1963.

The Dynasorb Energy Unit, developed in the Lockheed Engineering Laboratory, is adaptable to many applications as a shock absorber or load limiter. Design procedures based on previously reported data are described, and several typical installations are illustrated.

This report is submitted in fulfillment of the reporting requirements of a 1963 Independent Development Project, "Energy Absorption Products."

35. Mitchell, B., ENERGY ABSORPTION AT HIGH SPEED VERTICAL LANDING, Lockheed Report LR 21023, November 1967.

This report describes the use of the Lockheed Dynasorb energy absorber in landing impact tests of a 3400-lb simulated vehicle structure. The structure, released from a helicopter and tethered by parachute, impacted at a velocity of 112 feet per second.

36. Perrone, N., RESPONSE OF RATE SENSITIVE FRAMES TO IMPULSIVE LOAD, ASME Journal of Applied Mechanics, February 1971, pp. 49-62.

A relatively convenient method is presented herein to determine the plastic response of rate-sensitive frameworks. The technique represents a significant extension of usual limit analysis type approaches as well as similar efforts applied to rate insensitive structures.

The method consists of assuming a modal deformation pattern for the structure in question, determination of the initial modal velocity utilizing the appropriate criteria, and integration in some form of the equations of motion after estimating the magnitude of the dynamic yield moments at the rate-sensitive plastic hinge locations. It is recommended that an effective hinge length of the order of three beam depths should suffice in estimating the strain rate magnitude. For the perfectly plastic case, the dynamic yield moment is assumed to be a constant with time.

A square portal frame made of a solid rectangular cross-section and loaded under a horizontal impulsive load is considered in some detail. It is shown that a critical initial velocity exists.

The effects of strain hardening and pulse load application are considered. Minor modifications of the impulsively loaded, perfectly plastic situation are necessary to accommodate these extensions.

The usual limitations should be noted. It is assumed that buckling will not occur, that the median surface or membrane effects are negligible, and that elastic effects are negligibly small relative to plastic flow because the former are omitted.

Portal frame experiments under high intensity loading similar to those conducted at Brown University on cantilever beams would be most welcome. Most of the experiments performed to date have been in a much lower load range where elastic and plastic effects are of comparable order. The true limiting strength of the framework could be more completely assessed only if larger loads are applied. Other tests have been reported, and hopefully these results will soon be available.

37. Jones, N., INFLUENCE OF STRAIN-HARDENING AND STRAIN-RATE SENSITIVITY ON THE PERMANENT DEFORMATION OF IMPULSIVELY LOADED RIGID PLASTIC BEAMS, International Journal of Mechanical Science, 1967, Vol. 9, pp. 777-796.

A simple method is presented for estimating the combined influence of strain-hardening and strain-rate sensitivity on the permanent deformation of rigid-plastic structures loaded dynamically. A study is made of the particular case of a beam supported at the ends by immovable frictionless pins and loaded with a uniform impulse. The results of this work indicate that, when stress-hardening or strain-rate sensitivity are considered, permanent deformations are experienced which are similar to those predicted by an analysis retaining both effects simultaneously.

38. Ni, C. M., IMPACT RESPONSE OF CURVED BOX BEAM-COLUMNS WITH LARGE GLOBAL AND LOCAL DEFORMATIONS, General Motors Research Laboratory, Warren, Michigan, AIAA Paper 73-401.

A numerical approach based on a lumped-mass model is developed for investigating the impact response of curved box beam-columns with large global and local deformations. An empirical formula which relates the changes of depth and bending angle of a beam cross-section is obtained to take into account the local deformations of the cross-sections. The strain-hardening and the strain-rate properties of the material are considered in this analysis. The correlation between the present analysis and test results is very good. The results obtained indicate that the strain-wave propagations due to the impact and the strain-rate sensitivity of the material play the key roles in increasing the energy-absorbing capacity of the structure when subjected to high-speed impact.

39. O'Bryan, T.C., and Hatch, H.G., Jr., LIMITED INVESTIGATION OF CRUSHABLE STRUCTURES FOR ACCELERATION PROTECTION OF OCCUPANTS OF VEHICLES AT LOW IMPACT SPEEDS, NASA Technical Note D-158, 1958.

A limited investigation is made to determine the characteristics of three materials to see how they can be applied for human protection against accelerations encountered at low impact speeds. As a result, if given man's physiological tolerance to abrupt acceleration, which has not yet been well-defined, an alleviation system can be designed.

Foamed plastics require considerable depth to provide a given stopping distance for impact alleviation, and their use will require some control of rebound. They can be made soft enough to obtain the low onset of acceleration that may be necessary for man where depth is not limited.

Aluminum honeycomb is an efficient material for impact load alleviation from the standpoint of usable material depth, and it exhibits very little rebound. The stiffness of the material results in a very high initial onset rate of acceleration. For many installations this may be controlled by reducing the initial loading area of contact to get the material to start failing.

40. Jones, Norman, THE INFLUENCE OF LARGE DEFLECTION ON THE BEHAVIOR OF RIGID-PLASTIC CYLINDRICAL SHELLS LOADED IMPULSIVELY, Journal of Applied Mechanics, ASME, June 1970, pp. 417-425.

In order to gain some insight into the importance and influence of finite deflections on the response of shells loaded dynamically, this article studies theoretically the behavior of a cylindrical shell subjected to a uniform axisymmetric impulsive pressure. The cylindrical shell is assumed to be made from a rigid, perfectly plastic material, and the external energy imparted to the shell is much greater than the total strain-energy which can be absorbed elastically. The results of the investigation indicate that geometry changes are important and should be retained when studying the behavior of cylindrical shells loaded dynamically.

41. D'Amato, R., STATIC POST-FAILURE STRUCTURAL CHARACTERISTICS OF MULTI-WEB BEAMS, WADC TR 59-112, February 1959.

The structural behavior of aircraft components is discussed in relationship to the general lethality problem, the concept of post-failure restoring force for built-up structures of multiweb beams is considered, and a relatively simple analysis is developed to compute the static post-failure behavior of multiweb beams in pure bending. An experimental investigation is conducted to examine the validity of the analysis and, within the range of parameters considered, agreement between experiment and theory is satisfactory. Both the theoretical analysis and the experimental results indicated that an arbitrary extrapolation of post-failure data on the basis of ultimate strength can be very misleading.

42. Rawlings, B. ENERGY ABSORPTION OF DYNAMICALLY AND STATICALLY TESTED MILD STEEL BEAMS UNDER CONDITIONS OF GROSS DEFORMATION, International Journal of Mechanical Science, Pergamon Press, Ltd., 1967, Vol. 9, pp. 633-649. Printed in Great Britain.

An account is given of dynamic and static tests on mild steel members deformed under conditions of gross geometry change. An evaluation is made of the rigid-plastic theory, taking account of change of geometry, and also the elastic-plastic theory, assuming deformation to occur in the static mode, in predicting the behavior of the members.

43. Thompson, J.E., VEHICLE CRUSH PREDICTION USING FINITE-ELEMENT TECHNIQUES, Chrysler Corp., SAE Paper 73-157, January 1973.

The principal objective of this investigation is to develop analytical tools in the form of computer programs which will permit the automobile designer to predict the crush characteristics of a given car structure due to forces generated in a variety of impact modes.

The predictive or control capability is embodied in two large computer programs. "TELSAP" forms, reduces, and inverts the vehicle structure mass matrix expressed relative to a datum coordinate system and writes the mass matrix and its inversion onto a file for reading by the "CRUSH" program. "CRUSH" is a general matrix structural analysis program which calculates the large, plastic, rate-sensitive response of an interconnected beam structure due to known dynamic boundary displacement inputs. The theoretical bases and assumptions employed in developing these programs are described along with a detailed discussion of how the automobile design engineer might use them to develop a new vehicle structure.

Experimental correlation with the computer models is given for a vehicle-to-vehicle 90-degree intersection collision between a special rigid moving barrier and an intermediate-size four-door sedan. The structural model is further correlated with a laboratory test of a clamped-clamped beam struck at its center by an impact pendulum. The correlation indicates general agreement between experimental and analytical results.

By using the computer programs developed in this investigation, the automobile designer is able to reduce the amount of testing required to prove his design, and is able to identify the benefits of a particular structural reinforcement with a minimum of development time and expense.

44. Burgmann, J. B., and Rawlings, B., DYNAMIC PLASTIC ANALYSIS OF PIN-JOINTED FRAMES, International Journal of Mechanical Science, Pergamon Press, 1968, Vol. 10, pp. 967-980, Printed in Great Britain. (Revised 30 July 1968).

The paper presents an analysis of a pin-jointed frame subjected to dynamic or impulsive overload, of sufficient magnitude to cause permanent deformation. Rigid-plastic behavior of tensile members is assumed and, as a first approximation, a similar behavior of compressive members is assumed, although modifications to account for other characteristics are also discussed.

The behavior is considered in terms of the kinematic conditions, dynamic conditions, and the load-deformation characteristics assumed for the members.

45. Martin, J.B., MODE APPROXIMATION FOR IMPULSIVELY LOADED STRUCTURES IN THE INELASTIC RANGE, Proceedings of the Southampton 1969 Civil Engineering Material Conference.

A convergence approximation technique, based on the uniqueness proof, is reviewed for impulsively loaded rigid plastic and rigid viscoplastic structures. Emphasis is given to the use of mode or quasimode solutions and their usefulness in establishing a general approximating procedure and in providing insight into the important aspects of the gross structural response.

46. Jensen, W.R., Flaby, W.E., and Prince, N., MATRIX ANALYSIS METHODS FOR ANISOTROPIC INELASTIC STRUCTURES, AFFDL-TR-65-220, April 1966.

Most aerospace structural materials exhibit some degree of anisotropic strain-hardening. During the past few years, several methods have appeared in the literature for introducing inelastic isotropic material behavior effects into existing matrix analysis procedures using the incremental theory of plasticity. A review is presented of these methods and a step-by-step routine known as the "Constant Strain" method is selected for the development of an anisostropic inelastic procedure.

47. Isaakson, G., Armen, H., Jr., and Pipko, A., DISCRETE ELEMENT METHODS FOR THE PLASTIC ANALYSIS OF STRUCTURES, NASA CR 803, October 1967.

This study deals with the extension of finite-element methods to provide analytical means for determining the failure loads of aeronautical structures. Two areas are considered as related to predicting failure loads: inelastic stress analysis in the presence of load cycling, and plastic buckling of the bifurcation type.

Finite-element inelastic stress analysis methods are extended to take into account the Bauschinger effect for biaxial stress states using a plasticity theory based on Ziegler's modification to Prager's kinematic hardening theory. This methodology is applied to several structures representative of aeronautical construction, including a notched plate, a shear lag specimen, and a swept wing. Good correlation is obtained between analytical and experimental results for

the strains at the root of the notched plate subjected to load cycling in the plastic range.

Finite-element buckling methods are also extended to consider plastic buckling using Stowell's formulation for implementing a deformation plasticity theory into the buckling theory. Sample calculations are carried out for the plastic buckling of a flat plate with various geometries and edge conditions.

48. Stricklin, J.A., et al, NONLINEAR DYNAMIC ANALYSIS OF SHELLS OF REVOLUTION BY MATRIX DISPLACEMENT METHOD, AIAA Journal, Vol. 9, No. 4, April 1971, p. 629.

A formulation and computer program is developed for the geometrically nonlinear dynamic analysis of shells of revolution under symmetric loads. The nonlinear strain energy expression is evaluated using linear functions for all displacements. Five different procedures are examined for solving the equations of equilibrium, with Houbolt's method proving to be the most suitable. Solutions are presented for the symmetrical and asymmetrical buckling of shallow caps under step pressure loadings and a wide variety of other problems, including some highly nonlinear ones.

49. Owens, R. H., and Symonds, P.S., PLASTIC DEFORMATIONS OF A FREE RING UNDER CONCENTRATED DYNAMIC LOADING, ASME Journal of Applied Mechanics, December 1955, p. 524.

A concentrated time-dependent force acts on an unsupported thin ring along a diameter. The problem considered in this paper is to determine the deformations of the ring when the force magnitudes are such that plastic strains occur which are large compared to the elastic strains. By neglecting elastic strains and assuming ideally plastic behavior, approximations to the final deformations of the ring are obtained. The analysis is developed for force pulses of arbitrary shape, but numerical results are obtained only in the special case of a rectangular force pulse. A criterion is stated for conditions when this type of analysis can be expected to provide satisfactory results.

50. Lee, H., and Symonds, P.S., LARGE PLASTIC DEFORMATIONS OF BEAM UNDER TRANSVERSE IMPACT, ASME Journal of Applied Mechanics, September 1952, p. 308.

A comparatively simple method of analysis is developed to determine the deformations in a beam subjected to lateral impact of such a magnitude that plastic strains occur which are large compared with elastic strains. A useful approximation to the motion then can be obtained by neglecting elastic strains and considering rigid-body motion of segments of the beam joined at plastic hinges where the

entire deformation takes place. A method of analyzing such a situation is described and applied to a beam subjected to central impact. The approximate final permanent deformation is obtained; this includes deformation during application of the load, and plastic flow which continues afterward when the kinetic energy of the motion generated by the impact is transformed into additional plastic deformation. A criterion is given for conditions when this type of theory can be expected to provide a satisfactory analysis. The method of solution provides an interesting analogy to the concept of static determinacy which has been used in the analysis of quasi-static plastic-flow problems.

51. Prager, W., A NEW METHOD OF ANALYZING STRESSES AND STRAINS IN WORK-HARDENING PLASTIC SOLIDS, ASME Journal of Applied Mechanics, December 1956, p. 493.

For work-hardening plastic solids, segment-wise linear yield conditions and the associated flow rules constitute a reasonable compromise between the mathematically convenient but physically unsound total stress-strain laws and the physically sound but mathematically inconvenient incremental laws. They allow total stress-strain laws to be used in the small, but retain the characteristic features of the incremental laws in the large. The use of a segmentwise linear yield condition and the associated flow rule is illustrated by the analysis of the bending moments and deflections of a simply supported circular plate that is made of a work-hardening material and subjected to a uniformly distributed transverse load.

52. Morino, L., Leech, J.W., and Witmer, E.A., AN IMPROVED NUMERICAL CALCULATION TECHNIQUE FOR LARGE ELASTIC-PLASTIC TRANSIENT DEFORMATIONS OF THIN SHELLS, Part 1, ASME Journal of Applied Mechanics, June 1971, p. 423.

In this paper, the governing differential relations which describe the large-deflection elastic-plastic dynamic responses of arbitrarily shaped thin Kirchhoff shells are given, including recent improvements. These relations are then cast into finite-difference form for numerical solutions. These finite-difference relations are employed in a computer program, PETROS 2, which has been applied to evaluate the "analysis improvements" by comparing PETROS 2 predictions with those of the earlier analysis and with experimental results.

53. Pifko, A. Issakson, A FINITE-ELEMENT METHOD FOR THE PLASTIC BUCKLING ANALYSIS OF PLATES, Grumman Aerospace Corporation, Bethpage, N.Y., AIAA Journal of Applied Mechanics, Vol. 7, No. 10, October 1969.

An existing finite-element technique for elastic buckling of plates is extended to include the case of plastic buckling. The Stowell theory for the plastic buckling of flat plates is used in conjunction with the finite-element technique. Application is made to rectangular

plates, and results are presented for a variety of boundary support conditions and several different edge loading conditions.

54. Armen, H., Jr., Pifko, A., and Levine, H.S., FINITE ELEMENT ANALYSIS OF STRUCTURES IN THE PLASTIC RANGE, NASA CR 1649, February 1971.

The present report is concerned with the development of finite-element methods for the treatment of the nonlinear behavior of complex structures. It represents an extension of a previous study reported in NASA Contractor's Report CR-803. The nonlinearity may be of two types - material nonlinearity associated with plastic deformation, and geometric nonlinearity associated with the changing geometry of the structure as it deforms - or it may involve a combination of the two. Effects due to creep and other time-dependent material properties are neglected.

The methods developed are applicable to loading conditions that cause membrane stress states or pure bending, or both in combination. The Prager-Ziegler kinematic hardening theory of plasticity is incorporated in the finite-element methods to allow for consideration of the plastic response of structures subjected to realistic loading conditions, including cyclic loadings that cause stress reversals into the plastic range. Ideally, plastic behavior is also included to provide capability for predicting the collapse load of structures. The plasticity theory is implemented in the finite-element analysis by using an incremental approach in conjunction with the initial strain concept, with plastic strains interpreted as initial strains.

The treatment of geometric nonlinearity requires use of an incremental technique in which the internal forces and configuration of the structure are continuously updated to account for its changing geometry.

The methods developed are applied to a number of sample structures. For membrane stress states alone, the analysis employs a triangular finite element in which stress and strain vary linearly. This element is used for the plastic analysis of a variety of structures characterized by regions of rapid stress variation and subjected to cyclic loading resulting in reversed plasticity. Comparisons of the results of the analysis and experimental data indicate good correlation.

Plastic analyses are also performed for a variety of beam and plate structures. These problems make use of refined rectangular and triangular finite elements. Among the problems considered are rectangular, circular, and annular plates with various boundary conditions. Once again, comparisons with results of other available analyses are favorable.

Problems of combined bending and stretching of plates are also considered. Results are obtained for rectangular and circular plates. Results for combined geometric and material nonlinearity are presented for beams and arches.

55. Mallett, R. H., AUTOMATED METHOD FOR THE LARGE DEFLECTION AND INSTABILITY ANALYSIS OF THREE-DIMENSIONAL TRUSS AND FRAME ASSEMBLIES, AFFDL-TR-66-102, December 1966.

The computer program presented in this report was developed to predict large deflection behavior of three-dimensional truss and frame assemblies. The solutions are obtained by the direct minimization of the total potential energy with respect to the displacement variables rather than by solving nonlinear matrix equations. Sample problems are presented to demonstrate the analysis capability developed. Instructions for the preparation of the input data and the FORTRAN IV source program listing are included.

56. Przemieniecki, J.S., MATRIX METHODS IN STRUCTURAL MECHANICS, AFFDL-TR-66-80, Conference held October 26-28, 1965.

The Conference on Matrix Methods in Structural Mechanics held at Wright-Patterson Air Force Base on 26-28 October 1965 was sponsored jointly by the Air Force Flight Dynamics Laboratory, Research and Technology Division, Air Force Systems Command, and the Air Force Institute of Technology, Air University. The purpose of the conference was to discuss the recent developments in the field of matrix methods of structural analysis and design of aerospace vehicles.

57. Berke, L., PROCEEDINGS OF THE SECOND CONFERENCE ON MATRIX METHODS IN STRUCTURAL MECHANICS, AFFDL-TR-68-150, Conference held October 15-17, 1968.

The Second Conference on Matrix Methods in Structural Mechanics, sponsored by the Air Force Institute of Technology (AFIT), Air University, and the Air Force Flight Dynamics Laboratory (AFFDL), Air Force Systems Command, was held on 15-17 October 1968. The purpose of the conference is to discuss the recent developments in matrix structural analysis and design of structural systems. This volume contains all the papers presented at the conference.

Forty papers were presented at the conference in seven sessions, entitled Structural Weight Optimization, Dynamics, General Elements, Curved Elements, Applications, General Methods, and Nonlinear Analysis. The papers covered practically all major aspects of recent research and development work on matrix methods in structural mechanics.

58. Symonds, P.S., SURVEY OF TECHNICAL METHODS OF ANALYSIS FOR PLASTIC DEFORMATION OF STRUCTURES UNDER DYNAMIC LOADING, BU/NSRDC/1-67, Brown University, Providence, R.I., 1967.

This survey attempts to make a critical study of methods described in the literature for the analysis of metal structures under dynamic loading to plastic deformation.

Analyses have now appeared in the literature of a considerable variety of structures of engineering interest. They include beams (under many conditions of loading, support, and materials), rings, arches, frames, (simple rectangular bents), plates (circular and rectangular), membranes (i.e., plates with deflections greatly exceeding the thickness), and shells (axially symmetric loading on cylinders, spheres, and spherical caps). Most of these have been obtained by a rigid-plastic type of analysis (in which strain rates are assumed zero unless a yield condition is satisfied). A few have been obtained by wholly numerical approaches of finite-difference type.

Experiments reported in the literature have, in most cases, shown that the actual permanent deflections are smaller than those predicted on the basis of plastic properties determined by quasi-static tests, the predictions often being in error by as much as 100 percent or more for mild steel, with smaller discrepancies for other metals, such as aluminum alloys or high-strength steels. Strengthening under conditions of rapid straining has been considered the principal cause of such discrepancies; when it has been possible to modify the analysis to take account of the increase of yield and flow stresses at high strain rates, much better agreement has, in most cases,been obtained.

59. Semonian, J.W., and Anderson, P.A., AN ANALYSIS OF THE STABILITY AND ULTIMATE BENDING STRENGTH OF MULTIWEB BEAMS WITH FORMED CHANNEL WEBS, NACA Technical Note TN 3232, 1954.

Design curves and procedures are presented for calculating the stresses for instability and failure of multiweb beams with formed-channel webs. The ultimate bending strength of this type of construction is shown to depend upon the deflectional stiffness of the web attachment flanges. A simple criterion is also given for predicting whether a multiweb beam with a given attachment-flange design will be susceptible to a wrinkling instability or will buckle as if the webs are integrally joined to the cover skins.

The criteria for predicting buckling and failure stresses are compared with experimental data. These criteria are sensitive to the offset, pitch, and diameter of the rivets used on the web attachment flanges, and the riveting specification is, therefore, emphasized as an important design consideration.

60. Semonian, J.W., and Peterson, J.P., AN ANALYSIS OF THE STABILITY AND ULTIMATE COMPRESSIVE STRENGTH OF SHORT SHEET-STRINGER PANELS WITH SPECIAL REFERENCE TO THE INFLUENCE OF THE RIVETED CONNECTION BETWEEN SHEET AND STRINGER, NACA Technical Report TR 1255, 1956.

A method of strength analysis of short sheet-stringer panels subjected to compression is presented which takes into account the effect that the riveted attachments between the plate and the stiffeners have on the strength of panels. An analysis of experimental data shows that panel strength is highly influenced by rivet pitch, diameter, and location and that the degree of influence for a given riveting depends on the panel configuration and panel material.

A

Specific Contents and Areas of Applicability — REPORT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13
Elastic-Plastic Behavior	●			●	●	●		●	●	●	●	●	
Elastic Behavior	●			●		●	●	●	●		●		
Inelastic Behavior	●			●	●	●					●		●
Plastic Deformation				●		●						●	
Buckling				●		●	●			●		●	●
Analytical Procedures						●	●	●					
Linear Analysis	●					●	●	●					
Nonlinear Analysis	●				●	●							
Static Analysis									●				
Dynamic Analysis	●		●	●			●	●	●	●			
Analytical Programs	●			●							●		
Experimental Data	●			●		●	●			●	●		
Static Test	●			●									
Dynamic Test	●		●	●	●					●			
Load-Deflection Curves	●			●		●						●	
Airframe Structure	●	●		●		●	●	●					
Frame Structure					●	●	●						●
Beam Elements	●			●	●	●	●	●					
Columns, Bars, Tubes							●	●					●
Plates, Shells, Cylinders	●			●		●		●	●	●	●	●	
Composite Elements				●		●	●						
Large Displacements	●				●				●		●		
Design Procedures/Guidelines	●	●				●	●					●	
Simplified Analytical Techniques					●	●	●		●			●	
Inertia Effect	●							●					
Strain Rate Effects					●								
Energy Absorption	●	●	●	●									
Load-Limiting Devices		●											
Failure Modes	●			●					●			●	●

B

TABLE I. LITERATURE MATRIX CATEGORIZATION

3	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
	●	●	●	●	●		●	●	●														●	●	●		●	●	●	●			
				●								●					●		●	●	●	●			●			●					
●		●		●	●		●	●				●				●		●	●	●	●	●	●	●	●		●	●	●	●	●	●	●
				●	●	●	●						●				●	●					●	●	●		●	●	●	●	●	●	●
●		●	●													●	●			●								●			●		
	●	●		●			●	●															●	●	●		●	●	●	●	●	●	●
			●																														
	●	●	●	●																			●	●	●		●	●	●	●	●	●	●
			●													●				●								●				●	
				●	●			●	●		●							●					●	●	●		●		●	●	●	●	●
			●			●			●																								●
				●		●				●		●	●	●	●	●		●	●	●		●			●	●		●	●	●			
										●						●													●				
										●			●		●			●		●		●				●			●	●			
	●			●	●				●	●						●		●											●				
															●	●	●						●		●			●			●		
●								●															●					●		●	●		
	●			●		●										●							●	●	●					●			
●	●											●	●	●			●		●	●		●			●				●		●		
	●	●			●	●					●						●	●									●	●					
																												●					
				●	●		●								●								●	●	●			●	●	●	●	●	
											●					●	●				●												
					●						●												●	●	●			●			●		
											●														●		●			●			
						●												●					●	●	●		●		●	●		●	●
										●		●	●	●					●	●	●	●			●	●			●				
										●		●	●						●	●	●	●				●			●				
●												●																					

C

CATEGORIZATION

27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
									●	●	●		●	●	●	●				●	●		●	●	●	●	●		●	●	●		●
			●		●	●	●	●			●			●										●	●		●	●	●			●	
		●		●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●		●
			●	●					●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●		●	●	●
		●	●			●								●			●			●	●					●			●		●	●	●
									●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●
																												●	●				
									●	●	●		●	●	●	●	●	●	●	●	●				●	●	●		●	●	●		●
		●				●								●				●										●	●		●	●	
				●					●	●	●		●		●	●	●	●	●	●	●	●	●	●	●	●	●		●	●			●
																			●	●	●				●		●	●	●				●
●	●	●		●	●	●		●			●	●		●	●	●									●		●		●			●	●
		●													●																	●	
	●			●		●		●				●			●	●									●								
		●		●											●												●				●	●	
	●	●	●						●		●			●			●			●							●	●	●	●	●	●	●
									●					●		●	●			●								●	●	●			●
		●							●	●	●					●							●						●	●	●		●
●			●		●	●		●			●				●		●												●	●			●
			●	●									●	●						●	●			●	●	●	●		●	●			●
														●						●									●	●		●	●
	●								●	●	●			●	●	●	●	●				●	●	●	●	●	●		●	●	●	●	●
		●	●				●																										
									●	●	●			●			●				●							●	●				
											●		●			●							●	●	●		●		●				
				●					●	●	●		●		●	●		●	●	●				●					●				●
●					●	●	●	●			●	●			●																		
					●	●	●	●				●			●																		

TEST DATA

DYNAMIC TEST INSTALLATION

The dynamic test setup uses existing components. The drop carriage assembly is the same one that was utilized during the drop test of the fuselage bumper, the results of which are reported in Reference 1. Between the test specimen support and the ground are installed six load cells (two each along the north and south edges of the support and one each along the east and west edge of the support). The load cells are used for tests 7 and 8. In the previous dynamic tests (4, 5, 6), the specimen support is grouted to the concrete slab ground. The installation provides sufficient free-fall clearance (14 ft) to perform 30-ft/sec impact tests. The setup has the flexibility of performing higher impact velocity drop tests by adding additional frames, thus increasing the available free-fall distance. Figure 1 shows a layout of the test installation and notes the various items and assemblies that form a part of the complete installation.

TEST SPECIMENS

A complete description of the test specimen overall dimensions, bulkhead and end beam web thicknesses, number and thickness of angles, design configuration, nominal weight, and type of test performed for each specimen is shown in Volume I, Table XVII. A complete set of drawings for the various design configurations is presented herein as described in Table II below:

Table II. SPECIMEN DRAWING IDENTIFICATION

Figure	Applicable Specimen	Drawing X-16628A
2	1	-1
3	2,3,4	-2
4	5,6	-3
5	7,8,9	-4
6	10,11,12	-5

RECORDED SCAN (TIME) HISTORIES

A complete set of pertinent recorded test data is presented in Figures 7 through 80. Load-deflection curves for each of the test specimens are presented in Volume I in the section entitled Substructure Test Program.

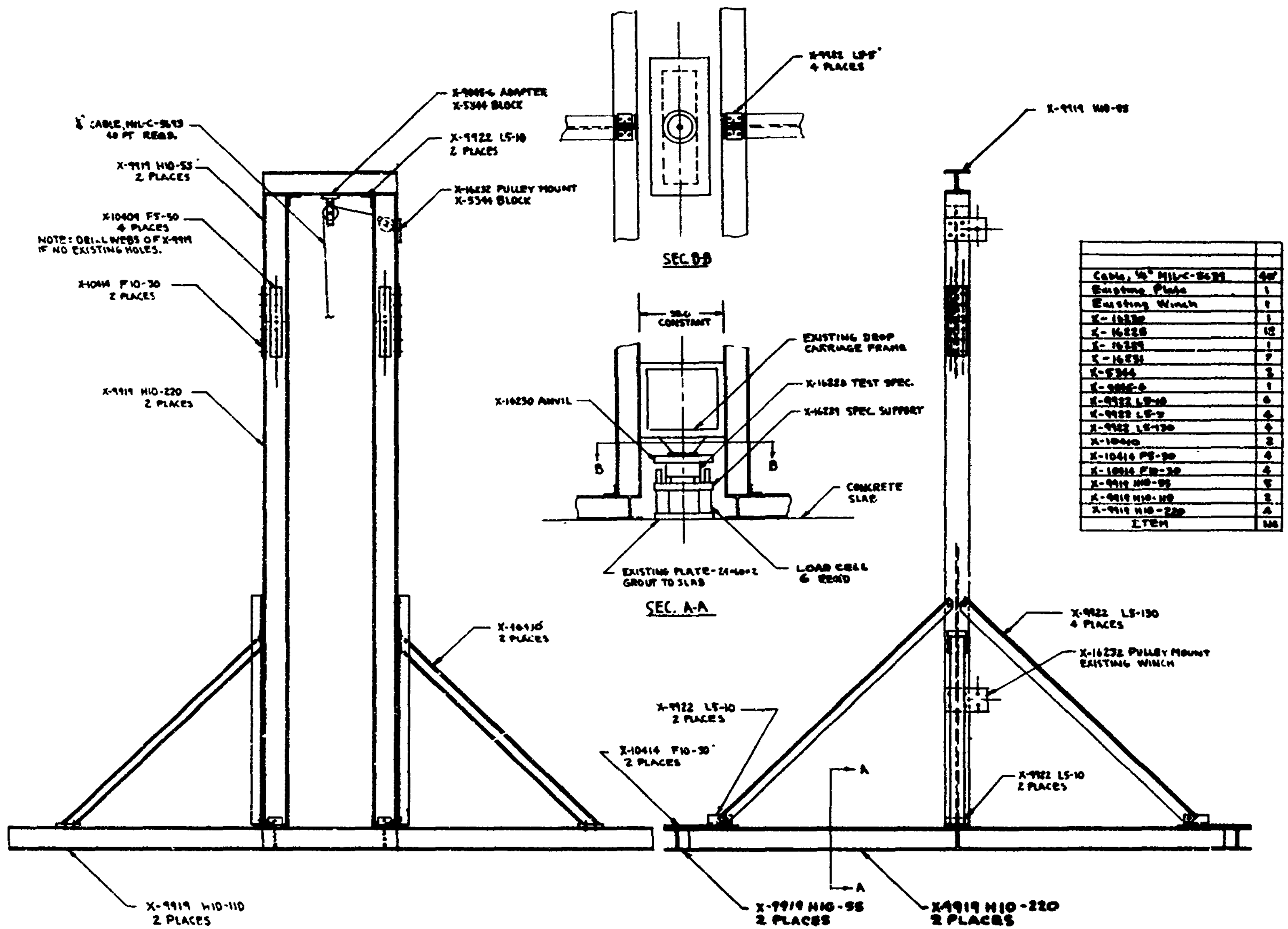


Figure 1. Dynamic Test Installation.

A

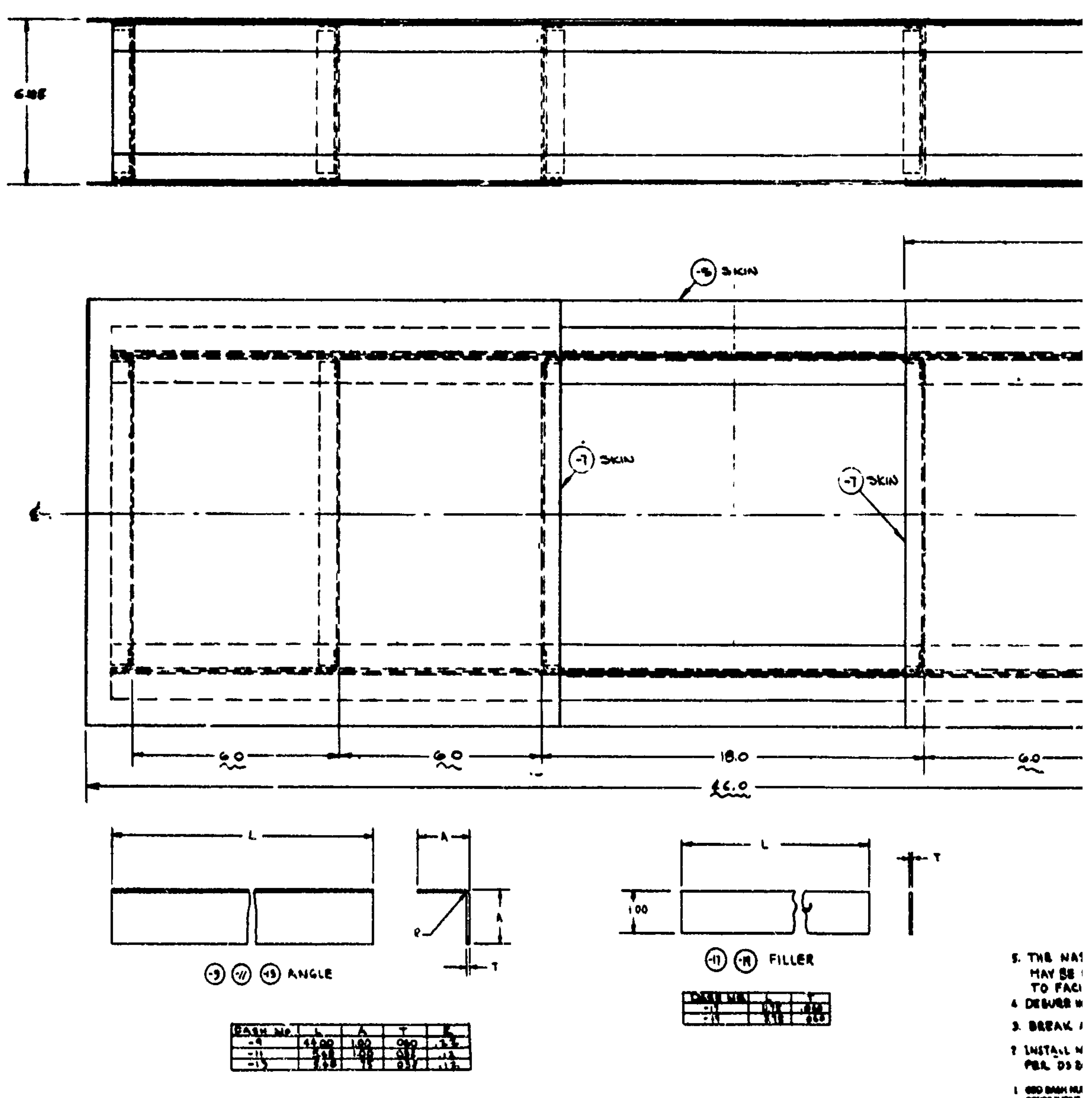
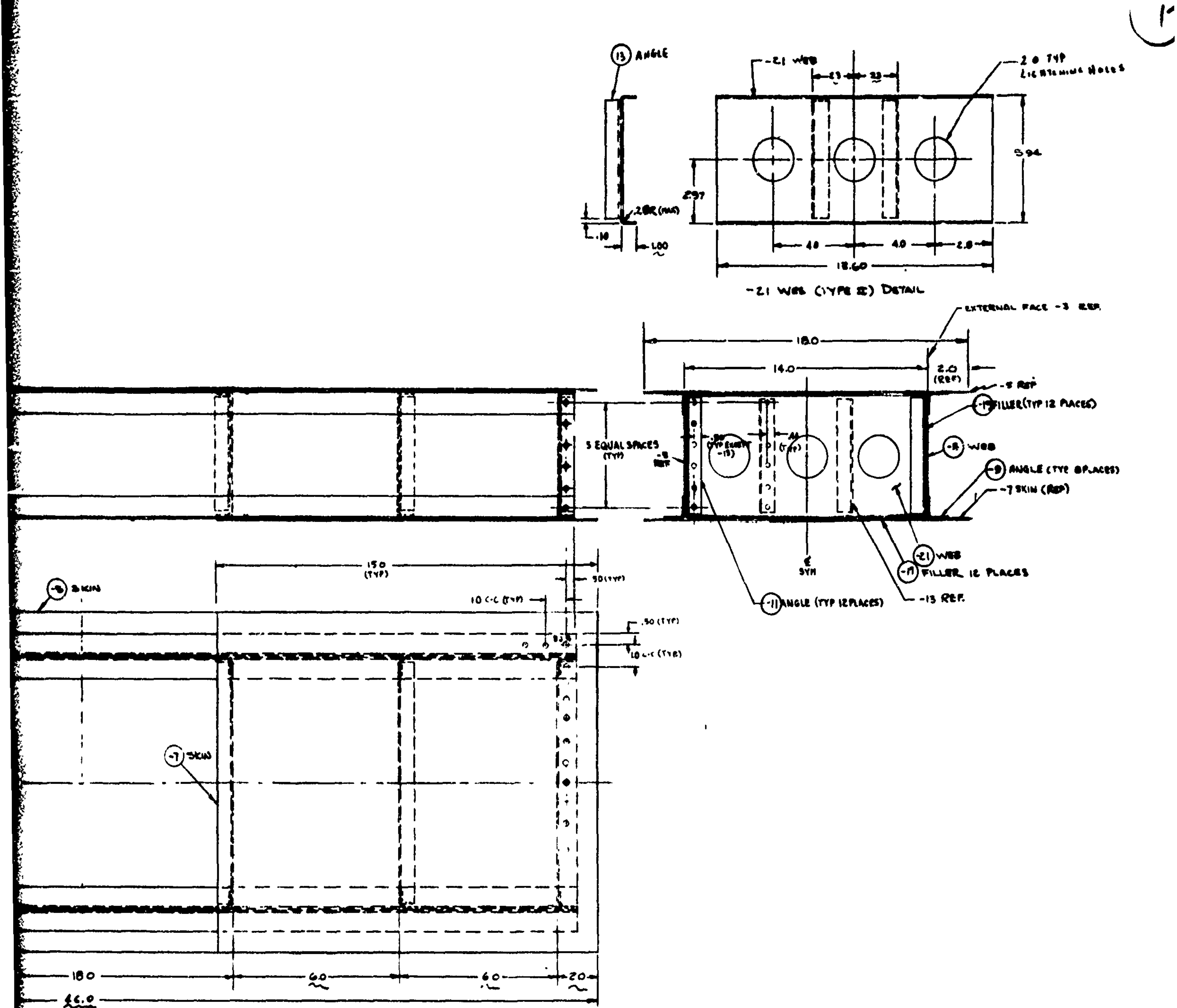
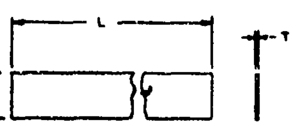


Figure 2. Drawing for Specimen 1.

Preceding page blank





(-17) (-19) FILLER

DASH NO.	L	T
-17	[illegible]	[illegible]
-19	[illegible]	[illegible]

5 THE NAS 1738B4( ) RIVETS MAY BE INSTALLED AT ANY LOCATION TO FACILITATE FABRICATION

4 DEBURR HOLES BEFORE ASS'Y

3. BREAK ALL SHARP EDGES

2 INSTALL NAS 1738E4-( ) RIVETS PER D3 3493

1 ODD DASH NUMBER SHOWN NEXT HIGHER CONSECUTIVE EVEN DASH NUMBER OPPOSITE.

NOTES:

		QUANTITY REQ'D PER SPECIMEN NO.		SYMBOL	NOMENCLATURE OR DESCRIPTION	CODE IDENT	PART OR IDENTIFYING NO.	MATERIAL SPECIFICATION	MATERIAL OR NOTES	SIZE OR SHAPE	UNIT WT	ZONE	HEAT TREAT
		A/R			RIVETS		MS20470AD4	[redacted]					
		6			WEB		-21	CLAD	7075 T6	.025 X 5 X 14			
		12			FILLER		-19		7075-T6	.040 X 1.0 X 1.75			
		12			FILLER		-17		7075-T6	.040 X 1.0 X 12			
		12			ANGLE		-13		2024 T3	.125 X 1/2 X	5⅞		
		12			ANGLE		-11		2024-T3	.032 X 2 X	5⅞		
		8			ANGLE		-9		2024 T3	.040 X 1 X 1 X	44		
		2			SKIN		-7		2024-T3	.125 X 18 X 15			
		1			SKIN		-5		2024 T3	.032 X 18 X 46			
		2			WEB		-3	CLAD	7075-T6	.032 X 5.87 X 44			
					ASSY								

LIST OF MATERIALS OR PARTS LIST

ecimen 1.

A

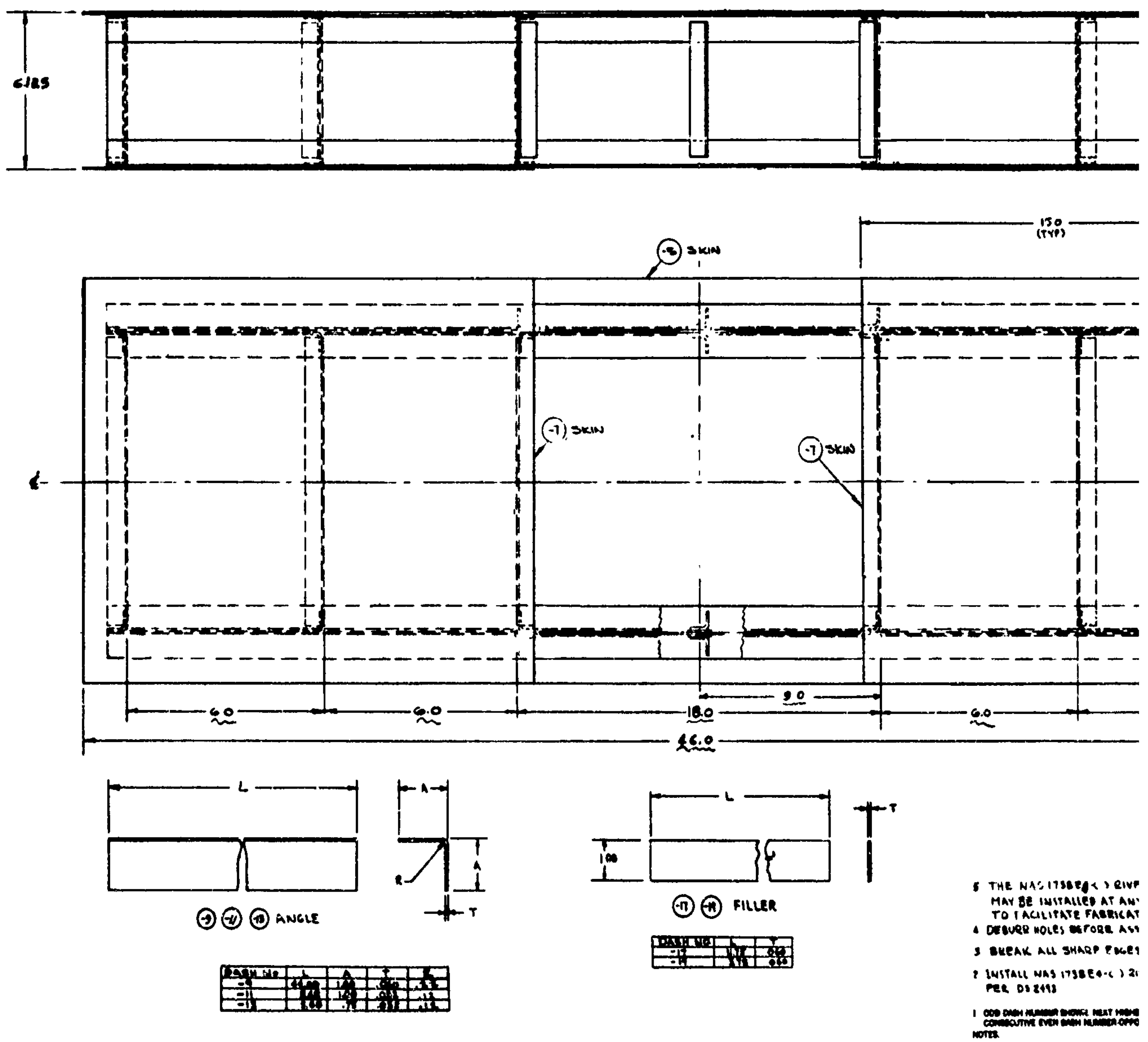
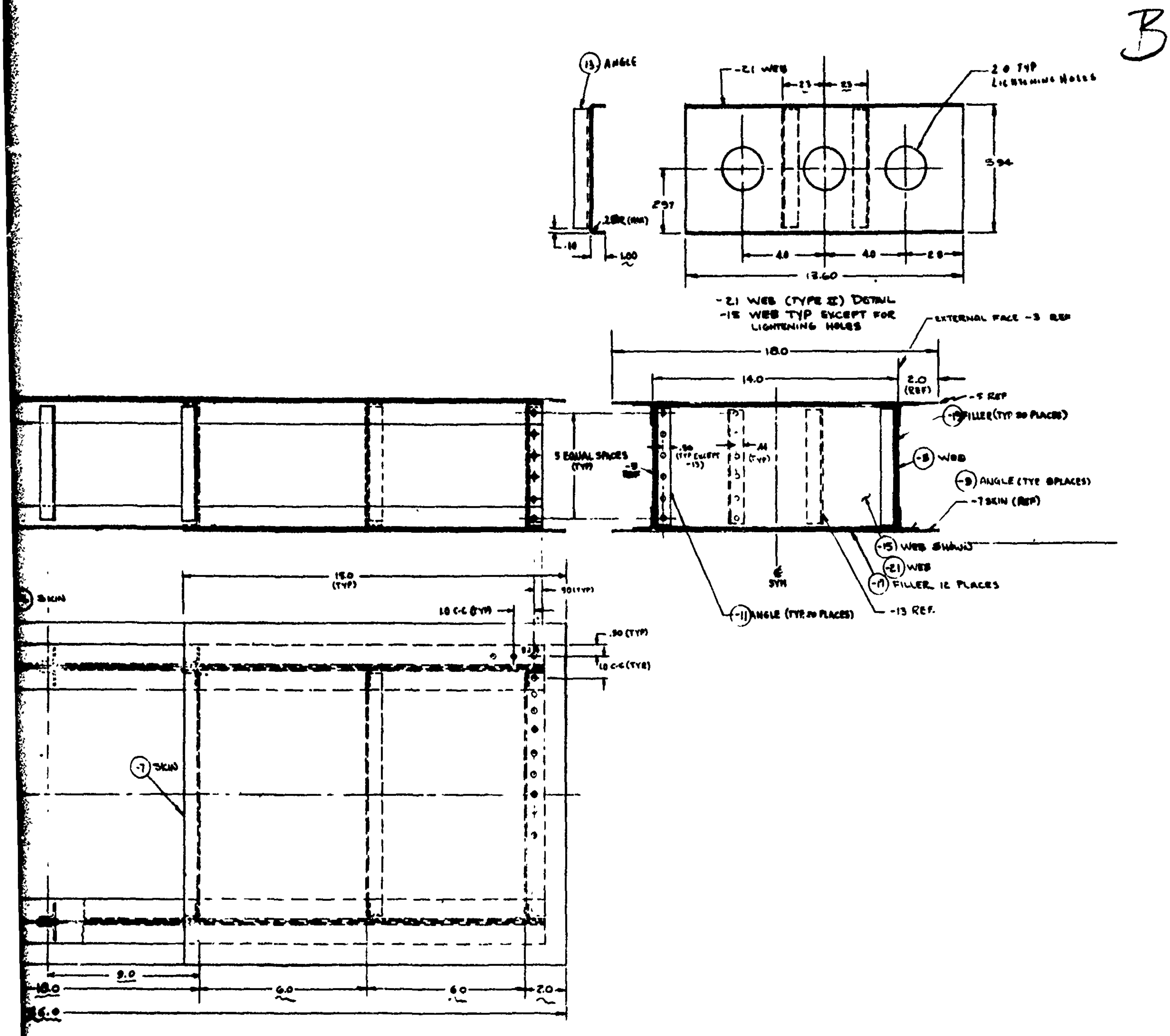
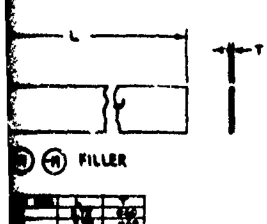


Figure 3. Drawing for Specimens 2, 3, and 4.

Preceding page blank 35





5. THE NAS 1738B(-) RIVETS MAY BE INSTALLED AT ANY LOCATION TO FACILITATE FABRICATION
4. DEBURR HOLES BEFORE ASSY
3. BREAK ALL SHARP EDGES
2. INSTALL NAS 1738E4-( ) RIVETS PER D12493
1. ODD DASH NUMBER SHOWN. NEXT HIGHER CONSECUTIVE EVEN DASH NUMBER OPPOSITE.

NOTES:

QUANTITY REQD PER SPECIMEN NO	#4	#3	#2	SYMBOL	NOMENCLATURE OR DESCRIPTION	CODE IDENT	PART OR IDENTIFYING NO	MATERIAL SPECIFICATION	MATERIAL OR NOTES	SIZE OR SHAPE	UNIT WT	ZONE	HEAT TREAT
	AR	AR	AR		RIVETS		MS20470AD4 [redacted]						
	6	6			WEB		-21	CLAD	7075-T6	.025 [illegible]			
	20	20	20		FILLER		-19		7075-T6	.064 x 1.0 x 1.75			
	12	12	12		FILLER		-17		7075-T6	.064 x .5 x 2			
			6		WEB		-15		7075-T6	.025 x 6 x 14			
	12	12	12		ANGLE		-13		2024-T3	.125 x 1/2 x	5.94		
	20	20	20		ANGLE		-11		2024-T3	.125 x 2 x	5.94		
	8	8	8		ANGLE		-9		2024-T3	.090 x 1 x 1 x	6.0		
	2	2	2		SKIN		-7		2024-T3	.032 x 18 x 15			
	1	1	1		SKIN		-5		2024-T3	.032 x 18 x 36			
	2	2	2		WEB		-3	CLAD	7075-T6	.032 x 5.87 x 36			
					ASSY								

LIST OF MATERIALS OR PARTS LIST

, 3, and 4.

A

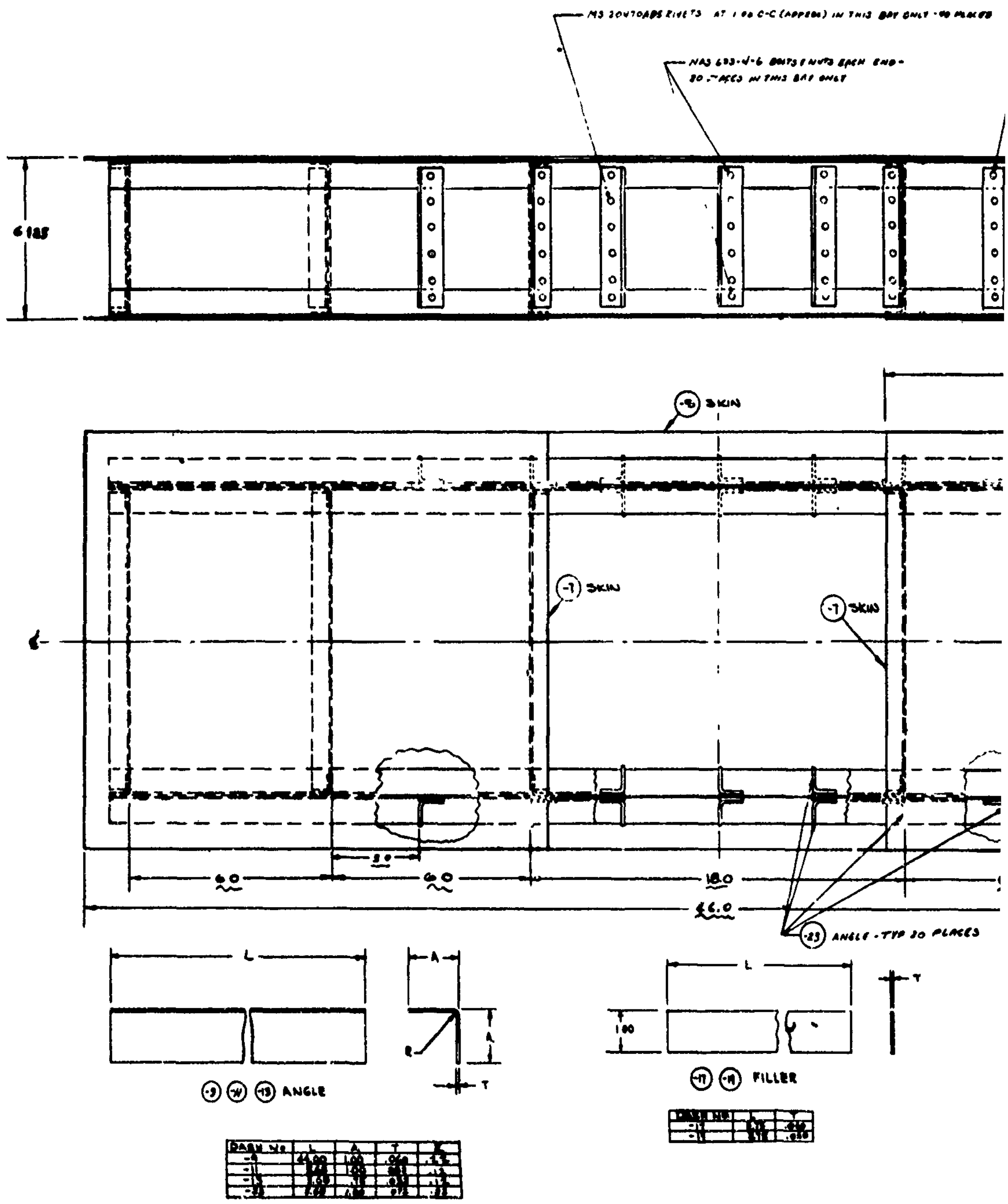
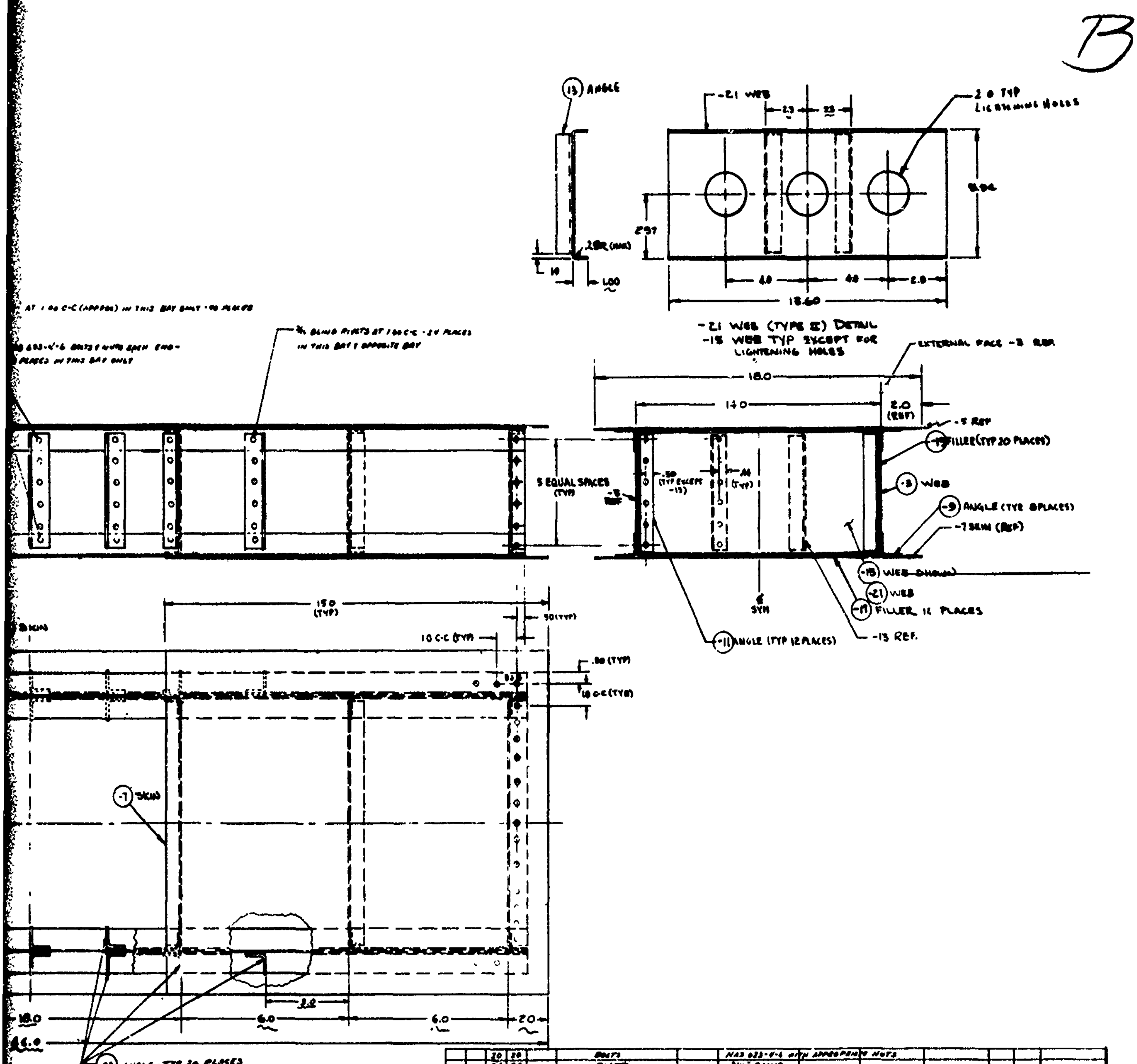
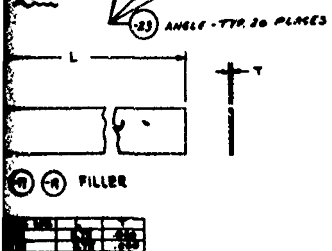


Figure 4. Drawing for Specimens 5 and 6.

Preceding page blank





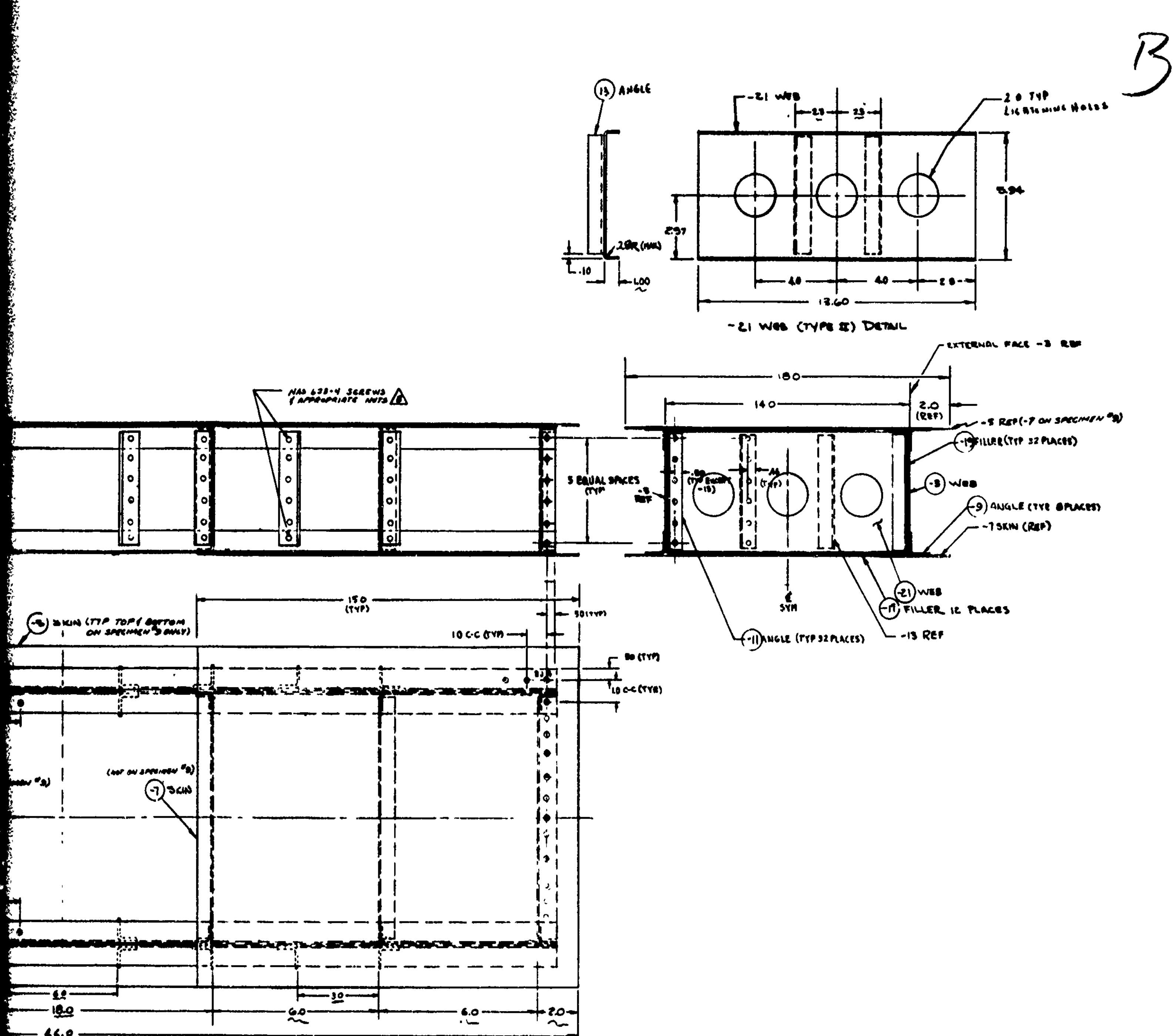
5. THE NAS 1738E4-( ) RIVETS MAY BE INSTALLED AT ANY LOCATION TO FACILITATE FABRICATION
4. DEBURR HOLES BEFORE ASS'Y.
3. BREAK ALL SHARP EDGES
2. INSTALL NAS 1738E4-( ) RIVETS PER DS 2413
1. ODD DASH NUMBER SHOWN. NEXT HIGHER CONSECUTIVE EVEN DASH NUMBER OPPOSITE.

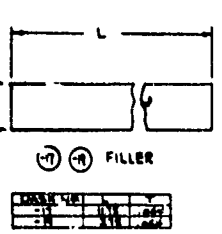
NOTES:

QUANTITY REQ'D PER SPECIMEN NO.		-5	-6	SYMBOL	NOMENCLATURE OR DESCRIPTION	CODE IDENT	PART OR IDENTIFYING NO.	MATERIAL SPECIFICATION	MATERIAL OR NOTES	SIZE OR SHAPE	UNIT WT	ZONE	ITEM WEIGHT
		20	20		BOLTS		NAS 623-4-6 WITH APPROPRIATE NUTS						
		24	24		RIVETS		3/16" BLIND						
		40	40		RIVETS		MS 20470AD6						
		20	20		ANGLE		-23	CLAD	2024-T3	.032 x 1 x 5 3/4			
		A/R	A/R		RIVETS		MS 20470 AD4 or	[redacted]					
		6			WEB		-21	CLAD	7075-T6	.025 x 8 x 14			
		20	20		FILLER		-19		7075-T6	.040 x 1.0 x 5.75			
		12	12		FILLER		-17		7075-T6	.040 x 1.0 x 1.2			
			6		WEB		-15		7075-T6	.025 x 8 x 14			
		12	12		ANGLE		-13		2024-T3	.032 x 1 1/2 x 5.8			
		12	12		ANGLE		-11		2024-T3	.032 x 2 x 5.8			
		8	8		ANGLE		-9		2024-T3	.040 x 1 5/16 x 6.4			
		2	2		SKIN		-7		2024-T3	.032 x 18 x 15			
		1	1		SKIN		-5		2024 T3	.032 x 18 x 46			
		2	2		WEB		-3	CLAD	7075-T6	.012 x 5.87 x 46			
					ASSY								

LIST OF MATERIALS OR PARTS LIST

5 and 6.





1. ATTACHMENTS AT ENDS OF ALL -11 ANGLES SHALL BE NAS 623-4 SCREWS AND APPROPRIATE NUTS
2. NAS 1738E4-( ) RIVETS USED IN LOCATION NOTED 'X' FOR SPECIMEN #9
6. RIVETS THRU SKINS TO BE AD4. ALL OTHER RIVETS TO BE AD5
5. REMOVED
4. DEBURR HOLES BEFORE ASSY
3. BREAK ALL SHARP EDGES
2. REMOVED
1. ODD DASH NUMBER SHOWN. NEXT HIGHER CONSECUTIVE EVEN DASH NUMBER OPPOSITE

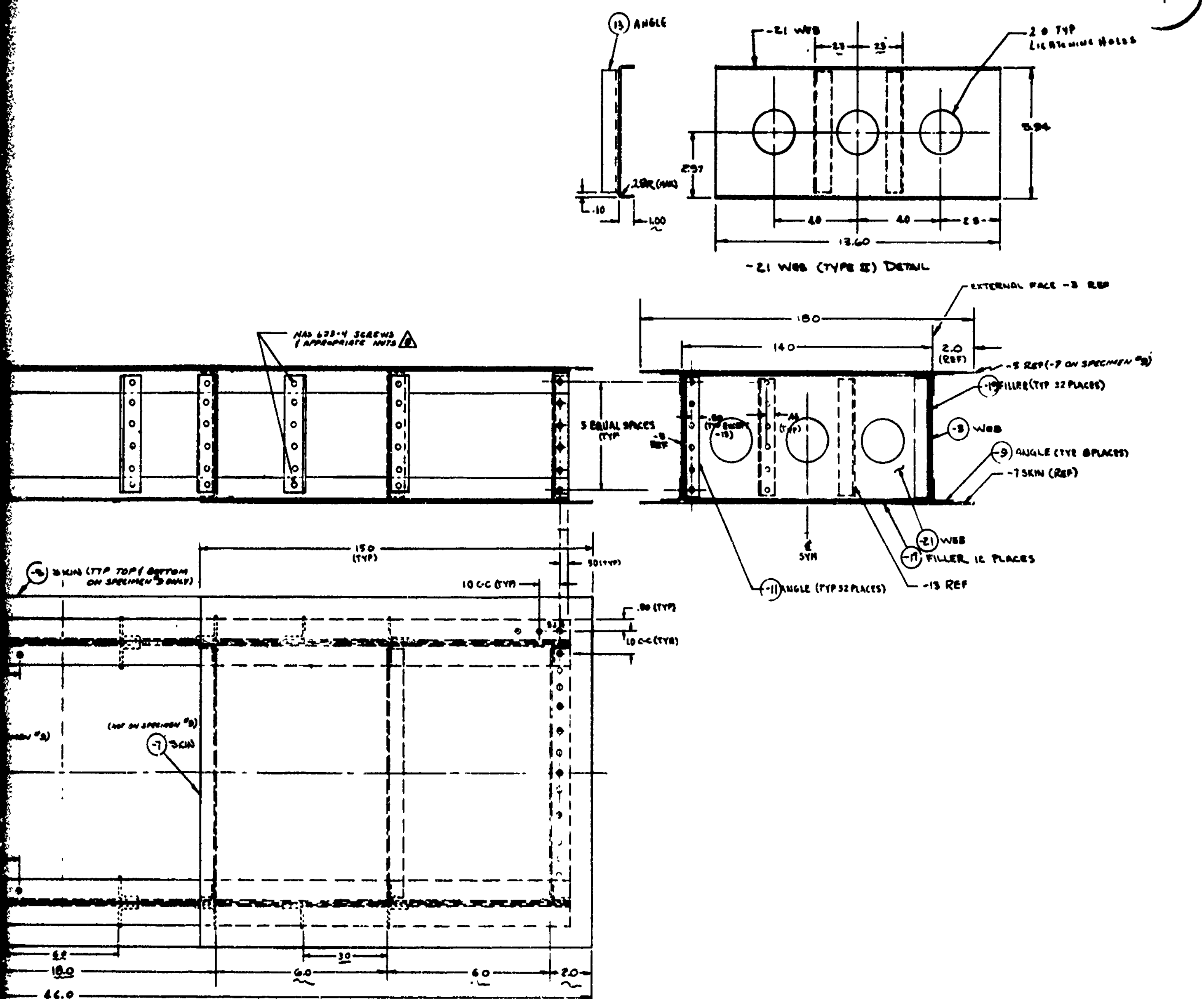
NOTES:

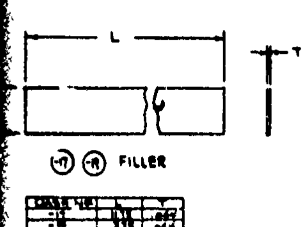
	Quantity Reqd per Specimen No -8	-9	-7	Symbol	Nomenclature or Description	Code Ident	Part or Identifying No.	Material Specification	Material or Notes	Size or Shape	Unit Wt	Zone	Heat Treat
		10			RIVETS		NAS 1738E4 ( )	BLIND RIVETS					
	A/R	A/R	A/R		BOLTS		NAS 625 V AND APPROPRIATE NUTS						
	A/R	A/R	A/R		RIVETS		MS20470AD5						
	A/R	A/R	A/R		RIVETS		MS20470AD4						
	6	6	6		WEB		-21	CLAD	7075-T6	[illegible]			
	32	32	32		FILLER		-19		7075-T6	.060 X 1.0 X 1.75			
	12	12	12		FILLER		-17		7075-T6	.060 X 1.0 X 12			
	12	12	12		ANGLE		-13		2024-T3	[illegible] X 5.94			
	32	32	32		ANGLE		-11		2024-T3	[illegible] X 5.94			
	8	8	8		ANGLE		-9		2024-T3	.060 X 1 X 1 X 6.6			
		2	2		SKIN		-7		2024-T3	.032 X 18 X [illegible]			
	2	1	1		SKIN		-5		2024-T3	.032 X 18 X 46			
	2	2	2		WEB		-3	CLAD	7075-T6	.064 X 5.87 X 44			
					ASSY								

LIST OF MATERIALS OR PARTS LIST

7, 8, and 9.

B





	10			RIVETS		NAS 1738EV ( )	BLIND RIVETS					
A/R	A/R	A/R		BOLTS		NAS 625 V and appropriate nuts						
A/R	A/R	A/R		RIVETS		MS20470AD5						
A/R	A/R	A/R		RIVETS		MS20470AD4						
6	6	6		WEB		-21	CLAD	7075-T6	[illegible]			
32	32	32		FILLER		19		7075-T6	.060X1.0X1.75			
12	12	12		FILLER		-17		7075-T6	.060X1.0X12			
12	12	12		ANGLE		-13		2024-T3	[illegible]	5.5		
32	32	32		ANGLE		-11		2024-T3	[illegible]	5.5		
8	8	8		ANGLE		-9		2024 T3	.060X1X1X	44		
	2	2		SKIN		-7		2024 T3	.032X18X1'			
2	1	1		SKIN		-5		2024 T3	.032X18X46			
2	2	2		WEB		-3	CLAD	7075-T6	.064X5.87X44			
				ASSY								
#8	#9	#7	SYMBOL	NOMENCLATURE OR DESCRIPTION	CODE IDENT	PART OR IDENTIFYING NO.	MATERIAL SPECIFICATION	MATERIAL OR NOTES	SIZE OR SHAPE	UNIT WT	ZONE	HEAT TREAT
QUANTITY REQD PER SPECIMEN NO				LIST OF MATERIALS OR PARTS LIST								

8. ATTACHMENTS AT ENDS OF ALL -11 ANGLES SHALL BE NAS 623-4 SCREWS AND APPROPRIATE NUTS
7. NAS 1738EV-( ) RIVETS USED IN LOCATION NOTED 'X' FOR SPECIMEN #9
6. RIVETS THRU SKINS TO BE AD6. ALL OTHER RIVETS TO BE AD5
5. REMOVED
4. DEBURR HOLES BEFORE ASSY
3. BREAK ALL SHARP EDGES
2. REMOVED
1. ODD DASH NUMBER SHOWN NEXT HIGHER CONSECUTIVE EVEN DASH NUMBER OPPOSITE

NOTES:

7, 8, and 9.

A

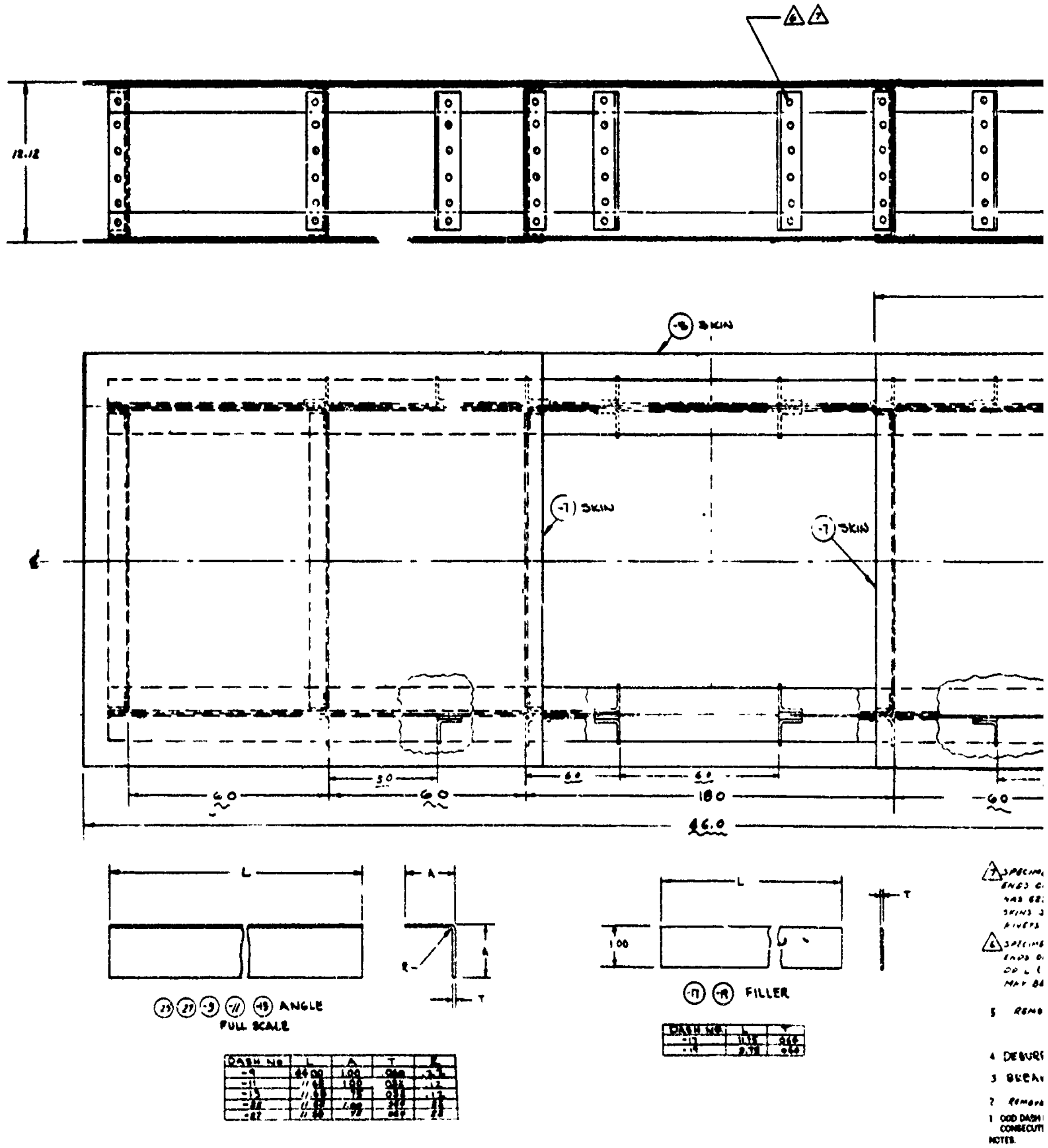
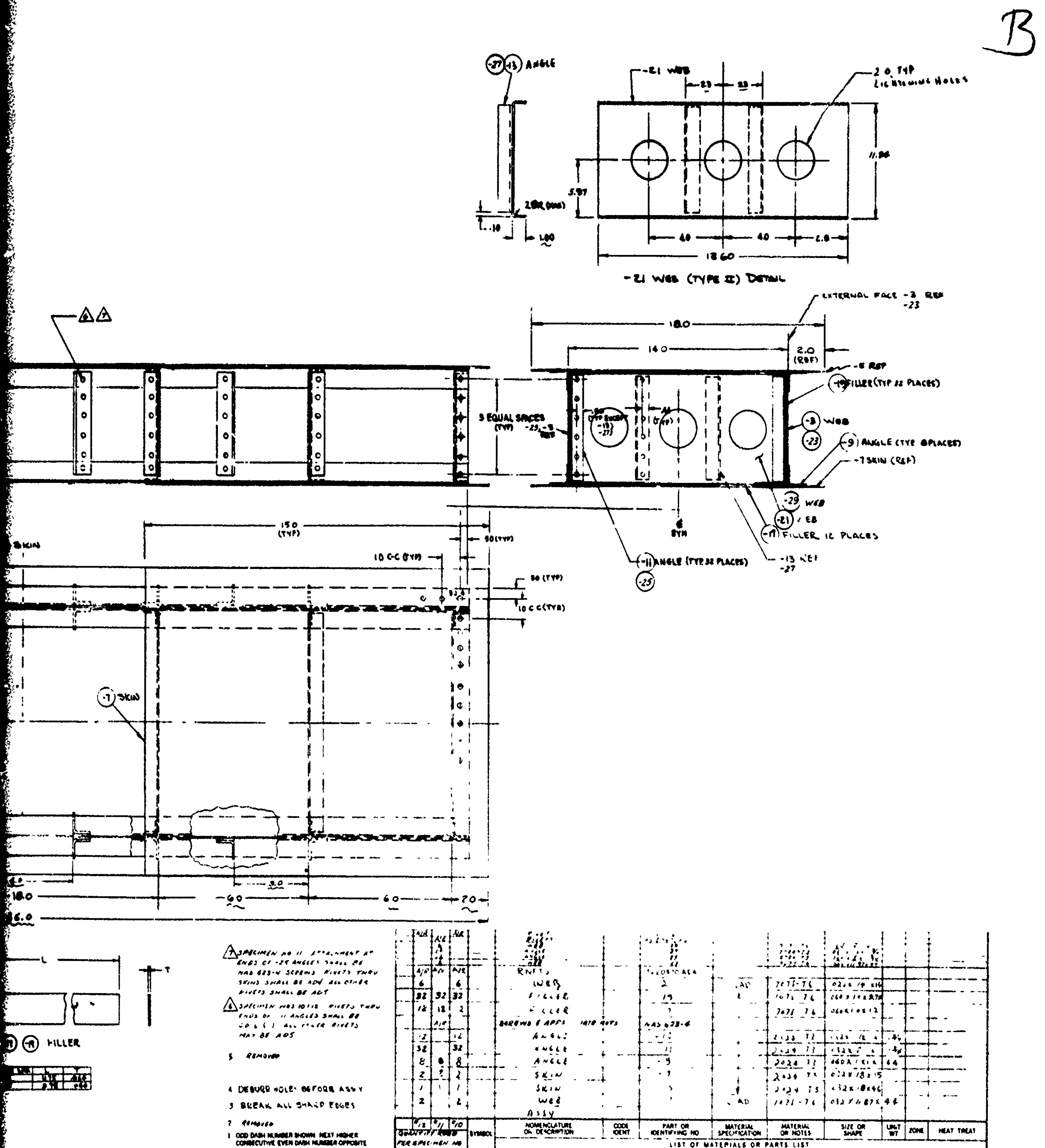


Figure 6. Drawing for Specimens 10, 11, and 12.

Preceding page blank



B
ANGLE
-21 WEB
2.0 TYP LIGHTENING HOLES
11.86
5.93
18.60
-21 WEB (TYPE II) DETAIL
EXTERNAL FACE -3 REF -23
18.0
14.0
2.0 (REF)
3 EQUAL SPACES (TYP)
FILLER (TYP 12 PLACES)
WEB
ANGLE (TYP 8 PLACES)
-7 SKIN (REF)
WEB
FILLER 12 PLACES
ANGLE (TYP 32 PLACES)
15.0 (TYP)
1.0 C-C (TYP)
.50 (TYP)
SKIN
-7 SKIN
3.0
18.0
6.0
6.0
7.0
16.0
FILLER
5 REMOVED
4 DEBURR HOLES BEFORE ASSY
3 BREAK ALL SHARP EDGES
2 REMOVED
1 ODD DASH NUMBER SHOWN NEXT HIGHER CONSECUTIVE EVEN DASH NUMBER OPPOSITE NOTES
QUANTITY REQD PER SPECIMEN NO
SYMBOL
NOMENCLATURE OR DESCRIPTION
CODE IDENT
PART OR IDENTIFYING NO
MATERIAL SPECIFICATION
MATERIAL OR NOTES
SIZE OR SHAPE
UNIT WT
ZONE
HEAT TREAT
LIST OF MATERIALS OR PARTS LIST

11, and 12.

The data in this section includes load, deflection, acceleration (tests 4-8) and strain versus scan plots. Table III shows the test data available in the section for each specimen.

The sampling rate for test 4 is 750 scans/second. The sampling rate for tests 5 through 8 is 1500 scans/second; thus for the dynamic tests the time in seconds can be obtained by dividing the abscissa scale (scan) by 750 for test 4 and by 1500 for tests 5 through 8. Positive strain is compression for tests 1, 2, 3, 9, 10, 11, 12 and tension for tests 4, 5, 6, 7 and 8.

Preceding page blank

Table III. TEST DATA IDENTIFICATION

Data Item	Test Specimen 1	2	3	4	5	6	7	8	9	10	11	12
Load	X	X	X				X	X	X	X	X	X
Deflection	X	X	X	X	X	X	X	X	X	X	X	X
Strain Gage 1A	X	X	X	X	X	X	X	X	X	X	X	X
Strain Gage 1B	X	X	X	X	X	X	X	X	X	X	X	X
Strain Gage 2	X	X	X	X	X	X						
Strain Gage 3	X	X	X									
Strain Gage 4	X	X	X									
Strain Gage 5	X	X	X									
Strain Gage 6	X	X	X	X	X	X						
Acceleration				X	X	X	X	X				
Applicable Figures	7 thru 13	14 thru 20	21 thru 29	30 thru 38	39 thru 44	45 thru 50	51 thru 60	61 thru 68	69 thru 71	72 thru 74	75 thru 77	78 thru 80

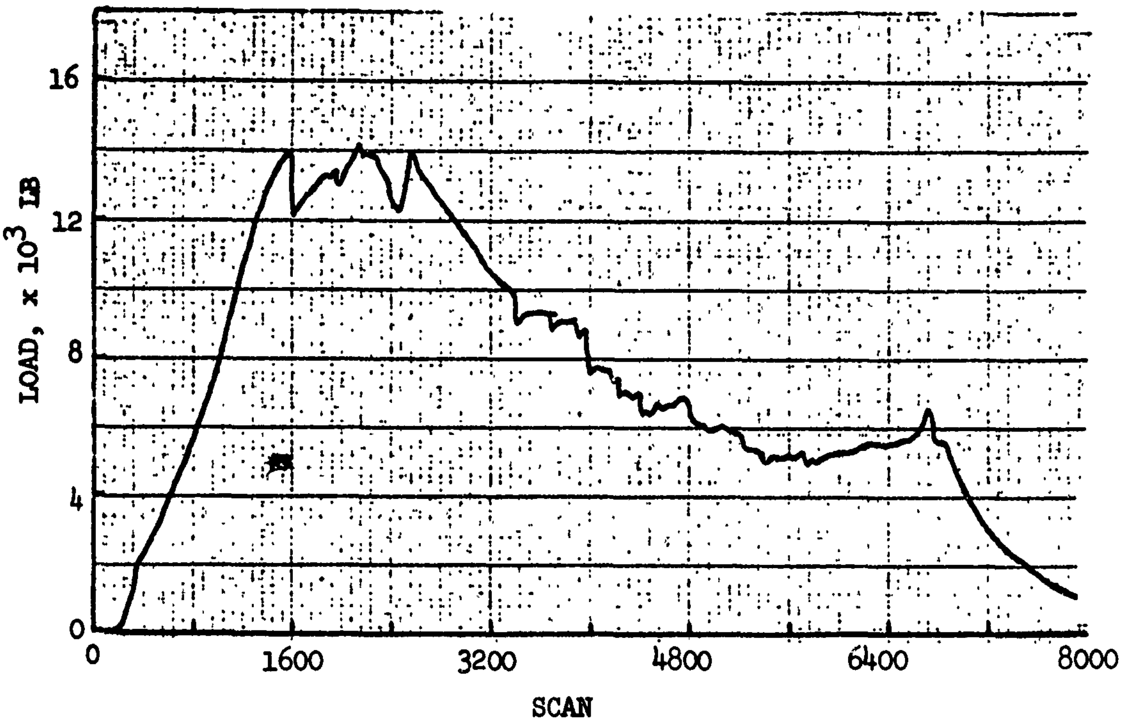


Figure 7. Load Versus Scan, Test Specimen 1.

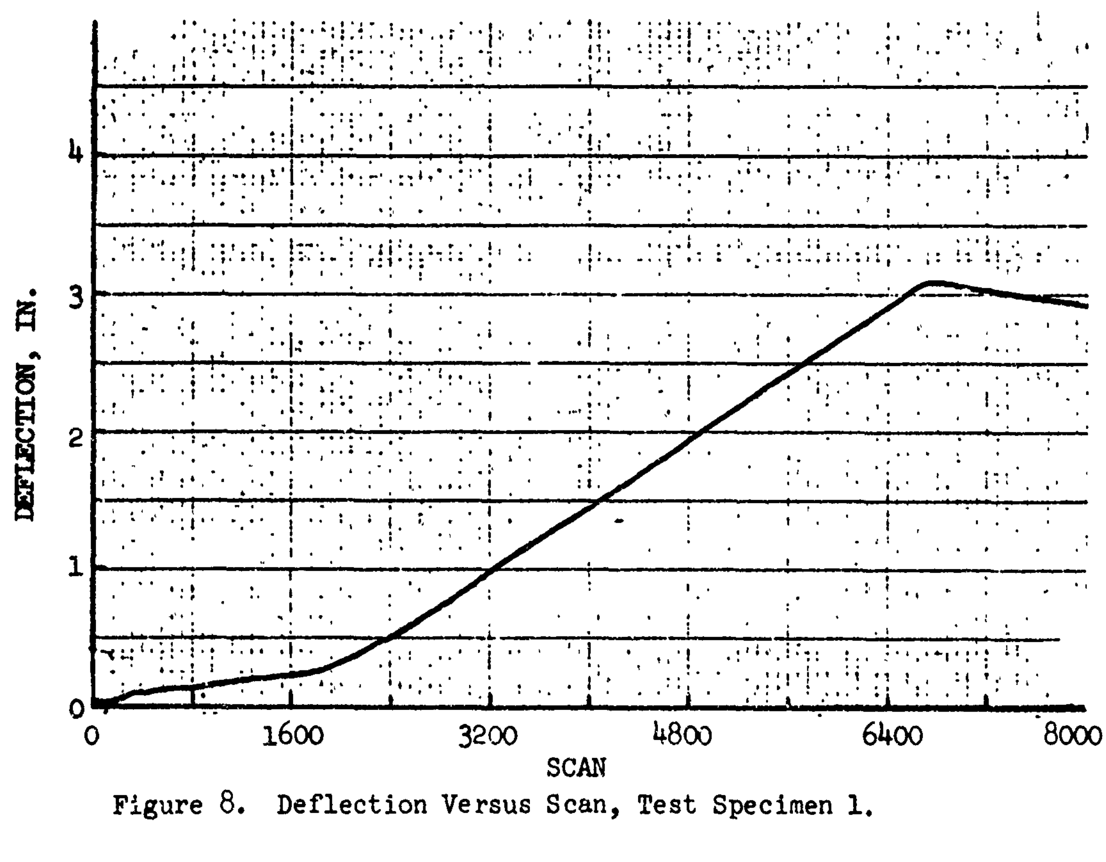


Figure 8. Deflection Versus Scan, Test Specimen 1.

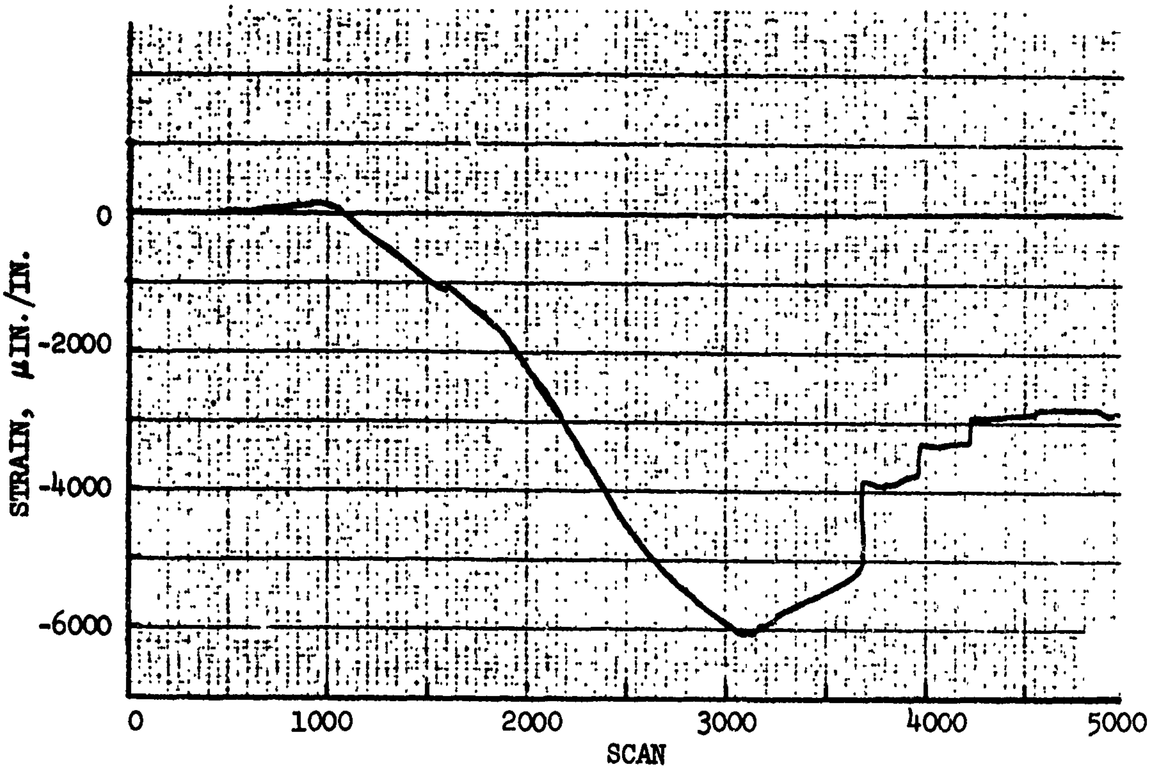


Figure 9. Strain Gage 1A Versus Scan, Test Specimen 1.

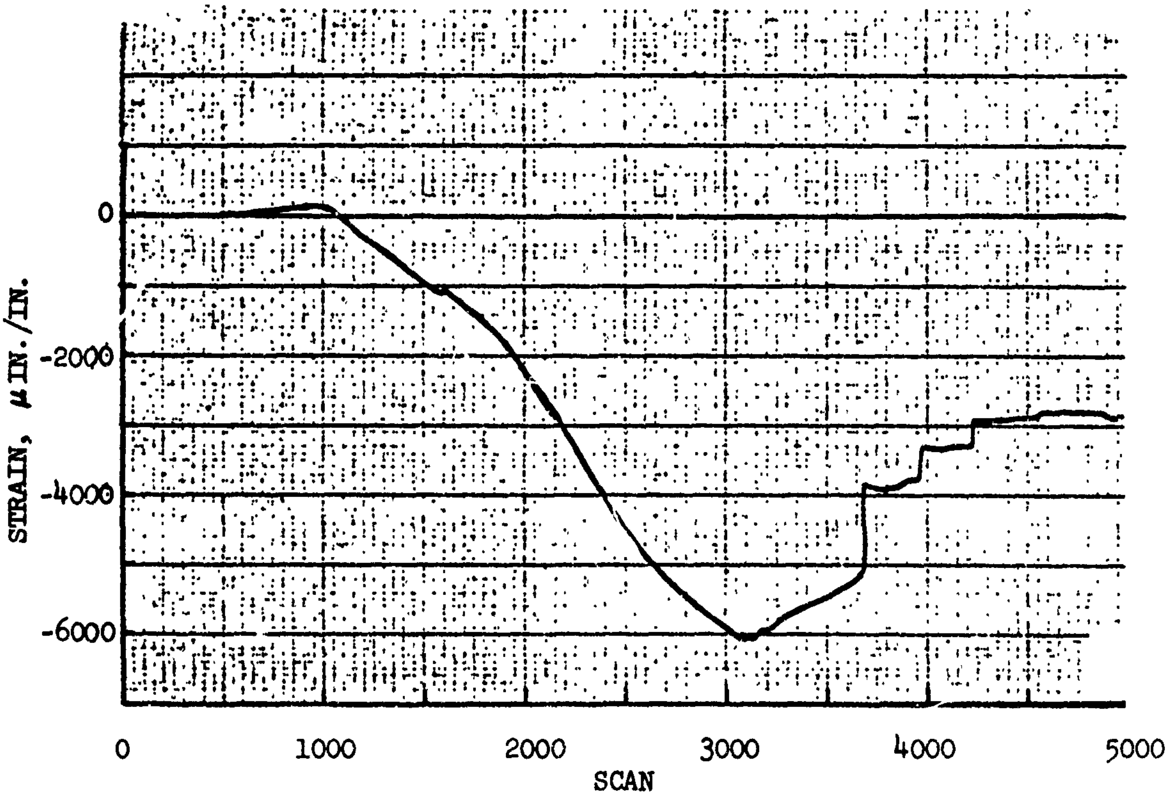


Figure 10. Strain Gage 1B Versus Scan, Test Specimen 1.

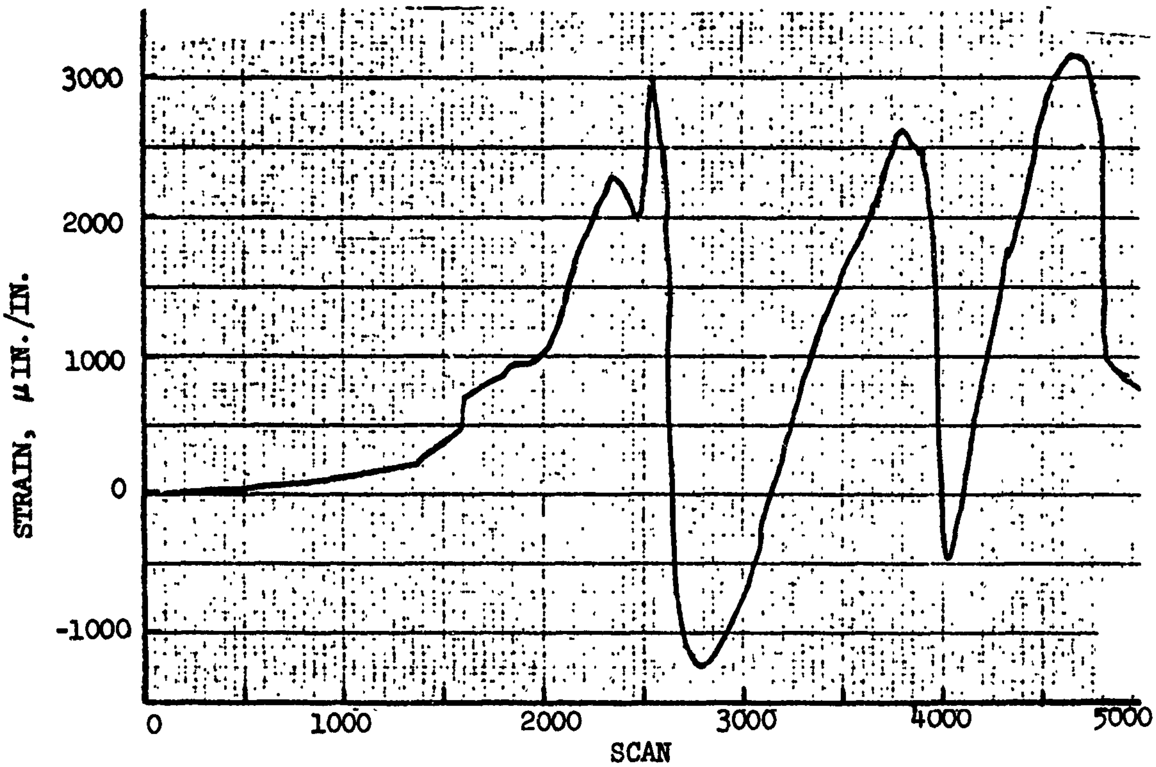


Figure 11. Strain Gage 2 Versus Scan, Test Specimen 1.

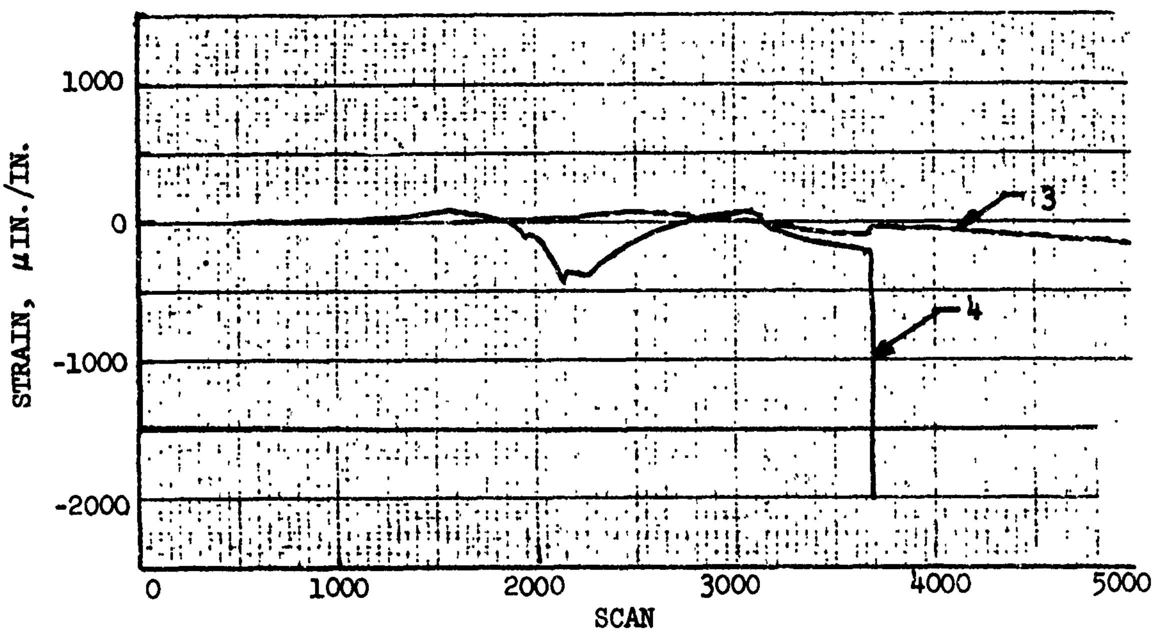


Figure 12. Strain Gages 3 and 4 Versus Scan, Test Specimen 1.

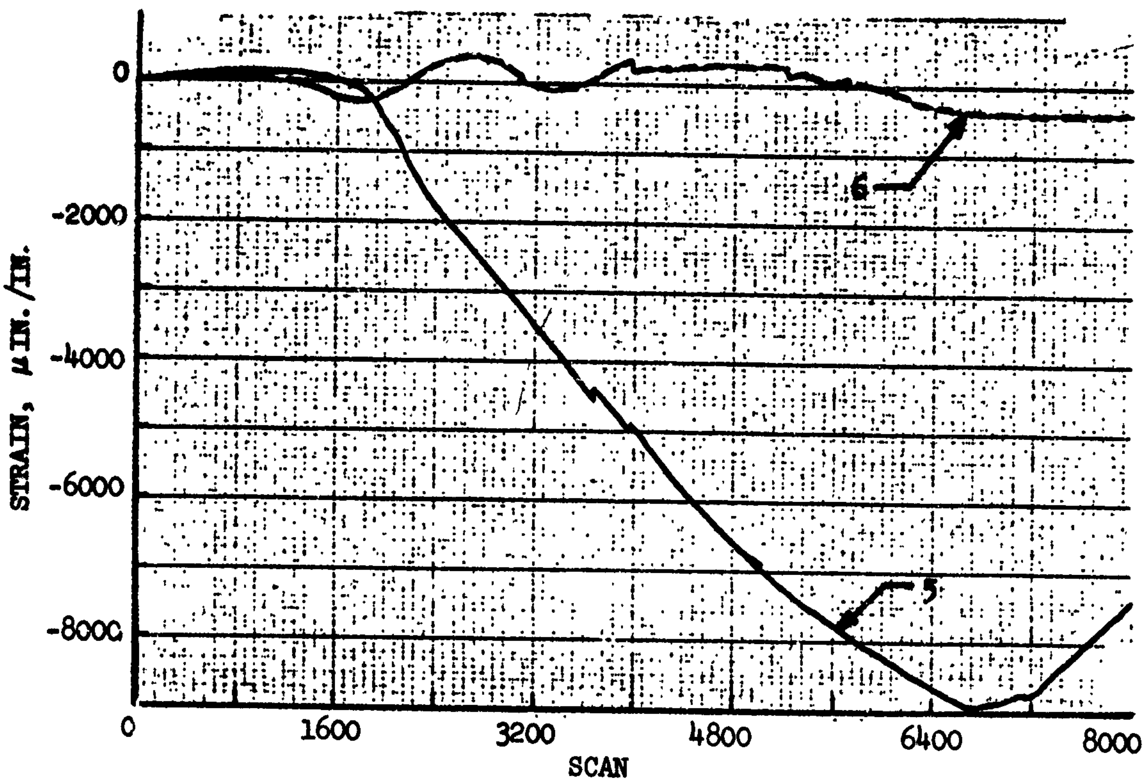


Figure 13. Strain Gages 5 and 6 Versus Scan, Test Specimen 1.

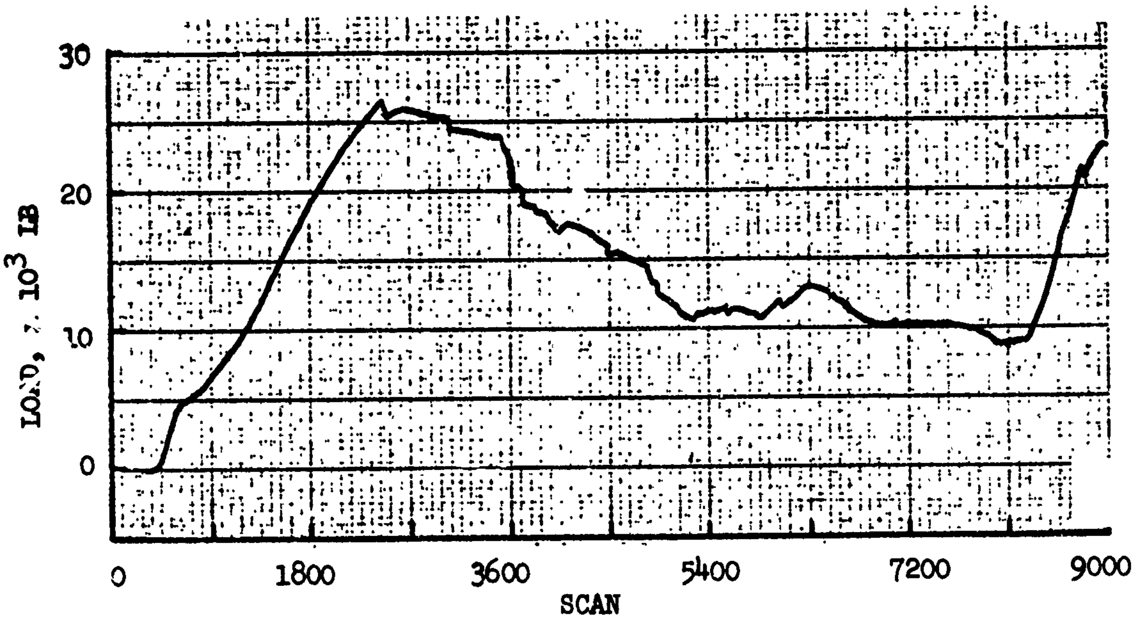


Figure 14. Load Versus Scan, Test Specimen 2.

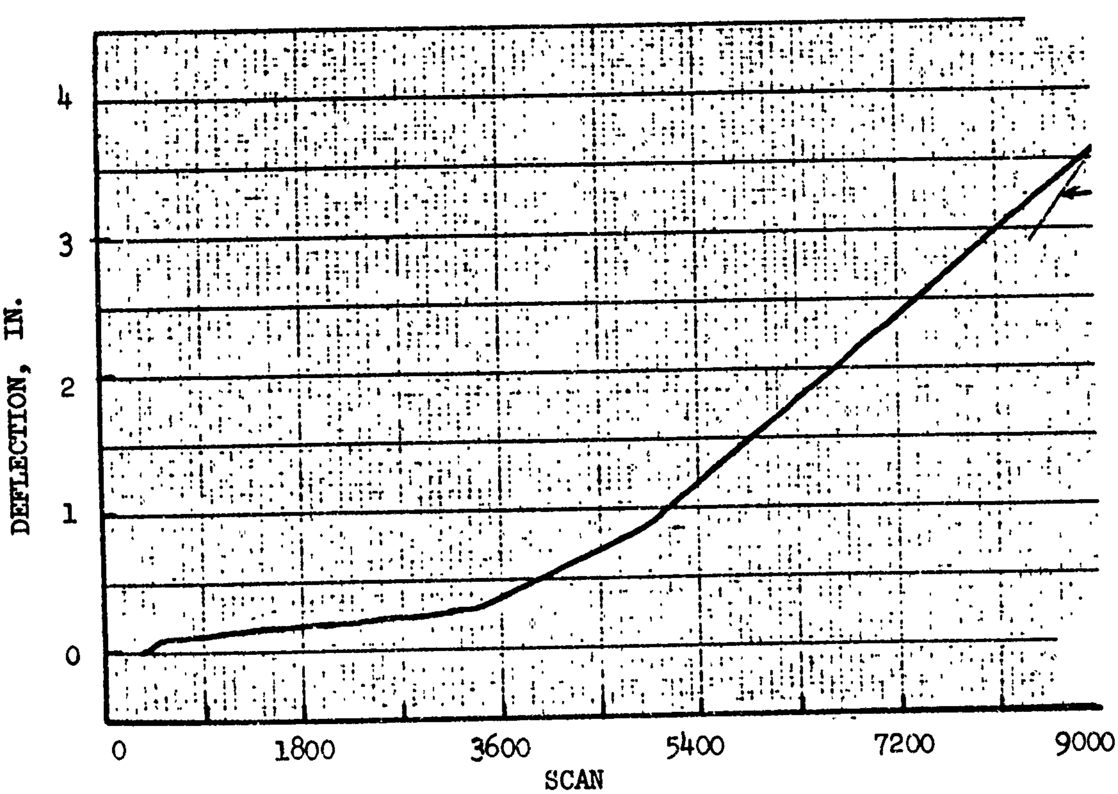


Figure 15. Deflection Versus Scan, Test Specimen 2.

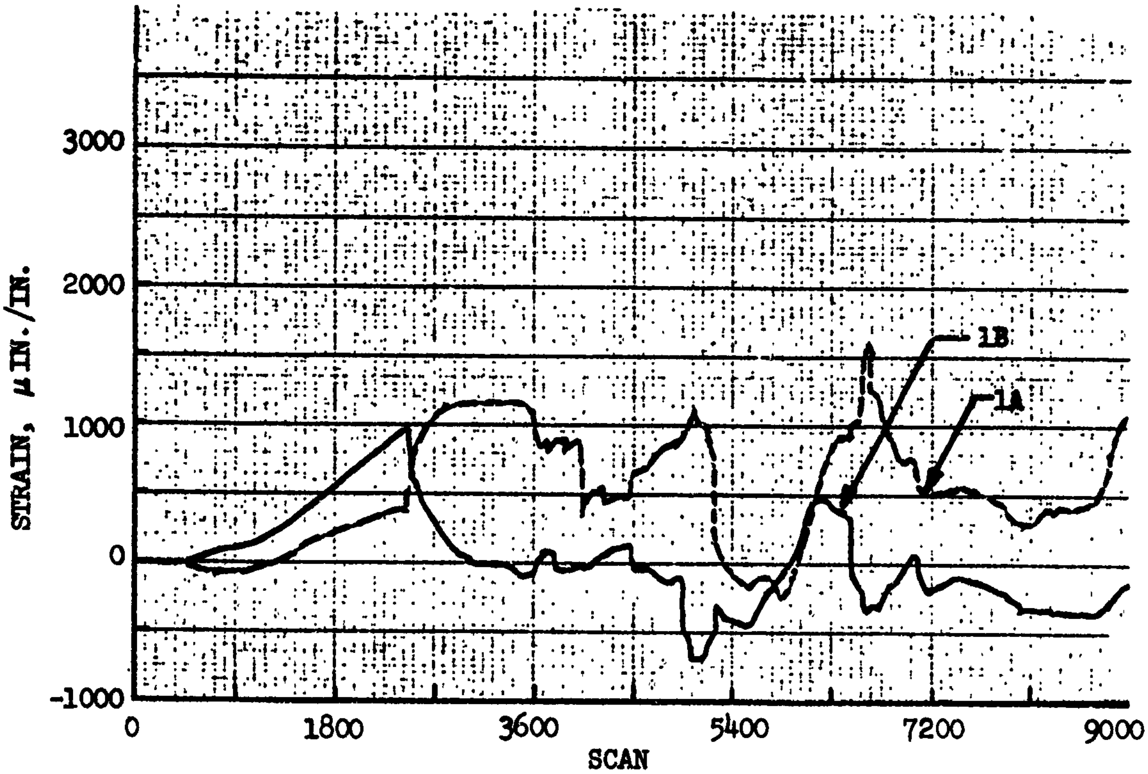


Figure 16. Strain Gages 1A and 1B Versus Scan, Test Specimen 2.

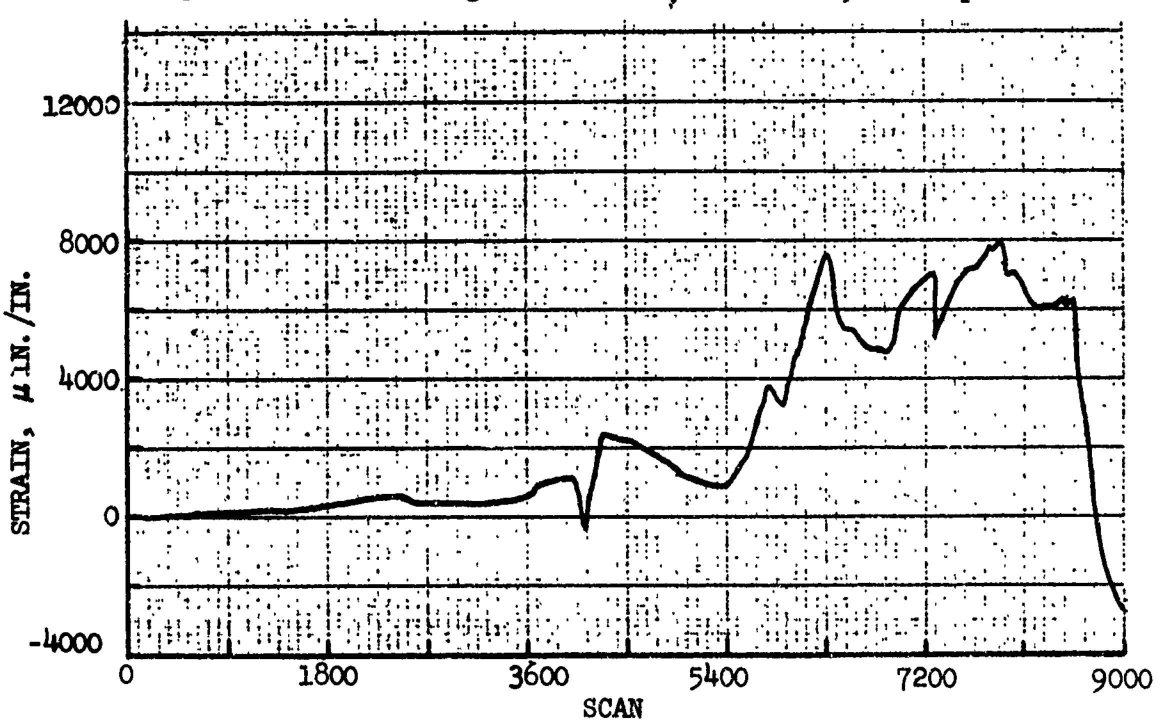


Figure 17. Strain Gage 2 Versus Scan, Test Specimen 2.

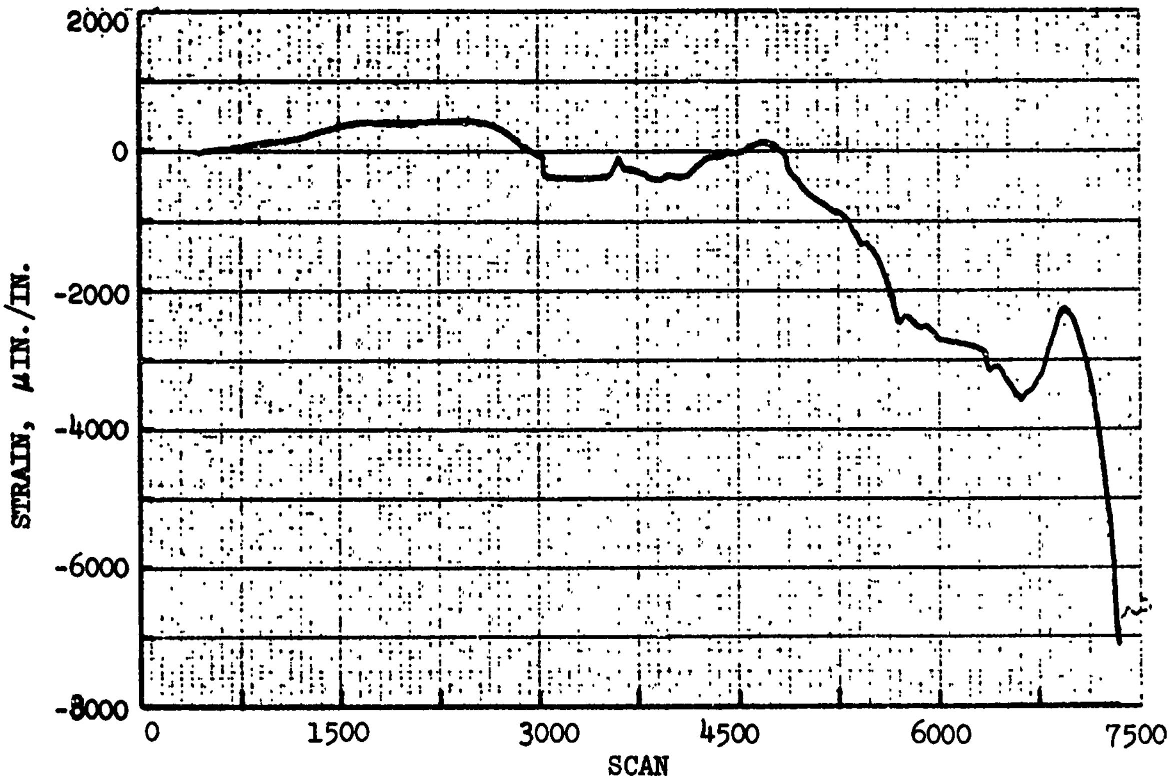


Figure 18. Strain Gage 3 Versus Scan, Test Specimen 2.

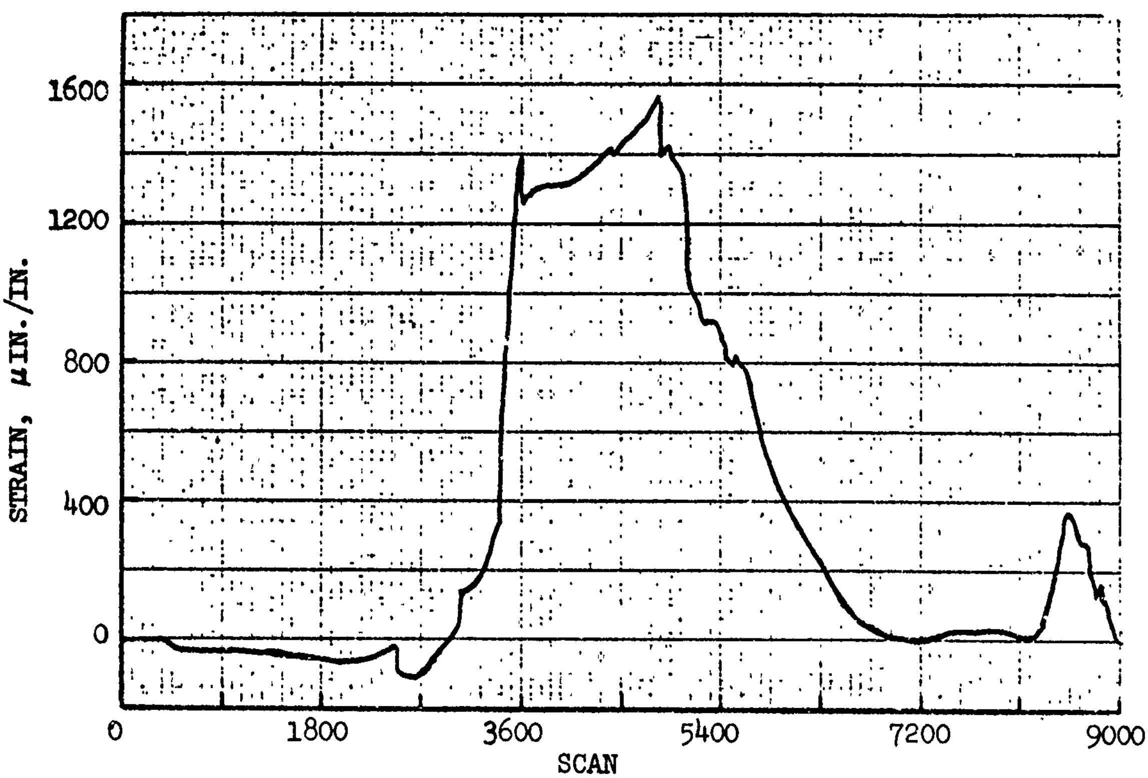


Figure 19. Strain Gage 4 Versus Scan, Test Specimen 2.

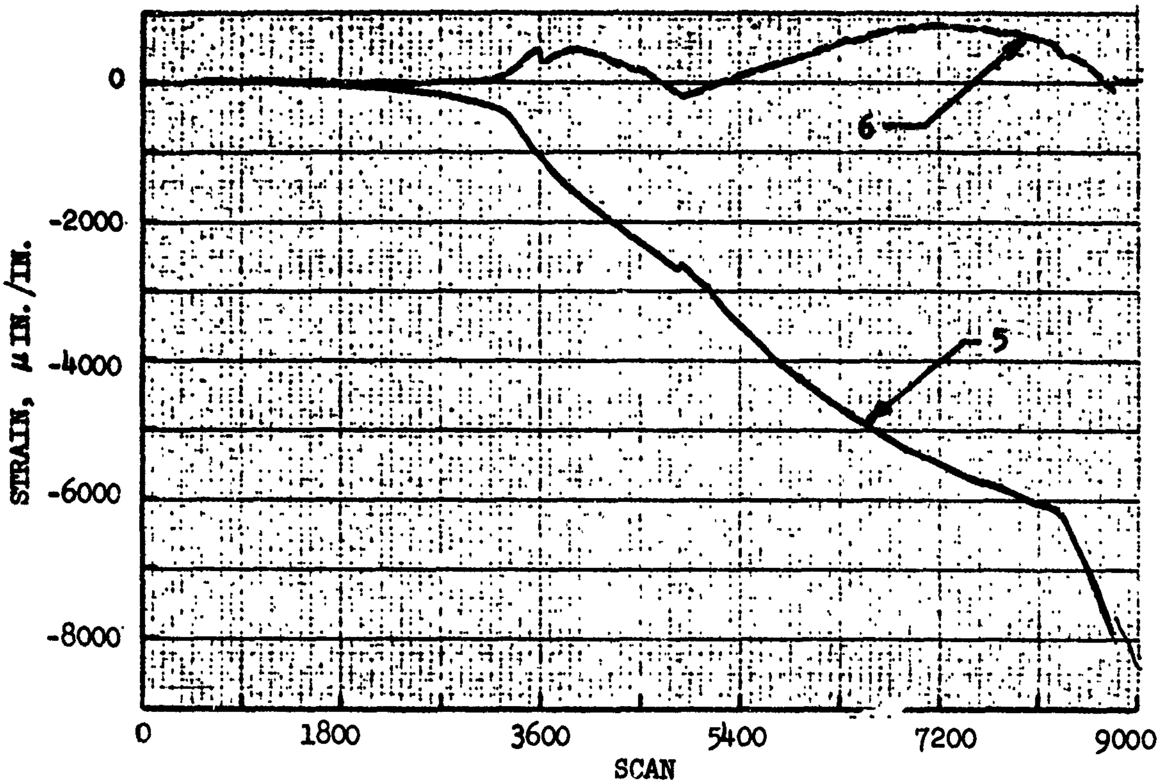


Figure 20. Strain Gages 5 and 6 Versus Scan, Test Specimen 2.

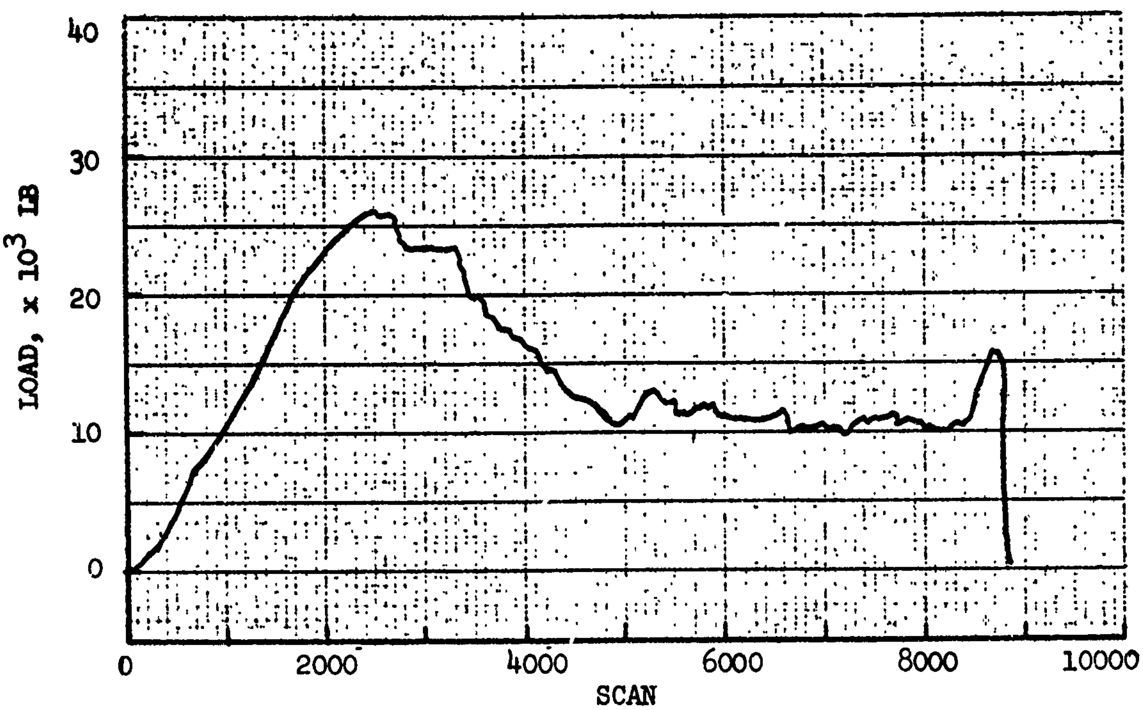


Figure 21. Load Versus Scan, Test Specimen 3.

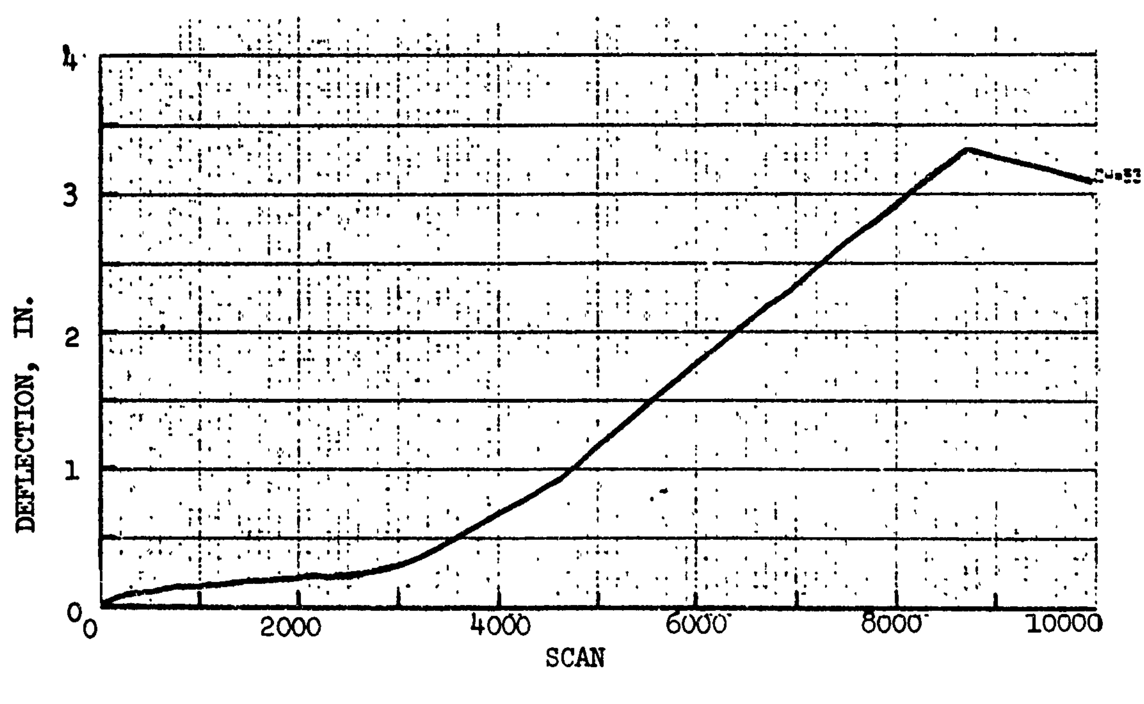


Figure 22. Deflection Versus Scan, Test Specimen 3.

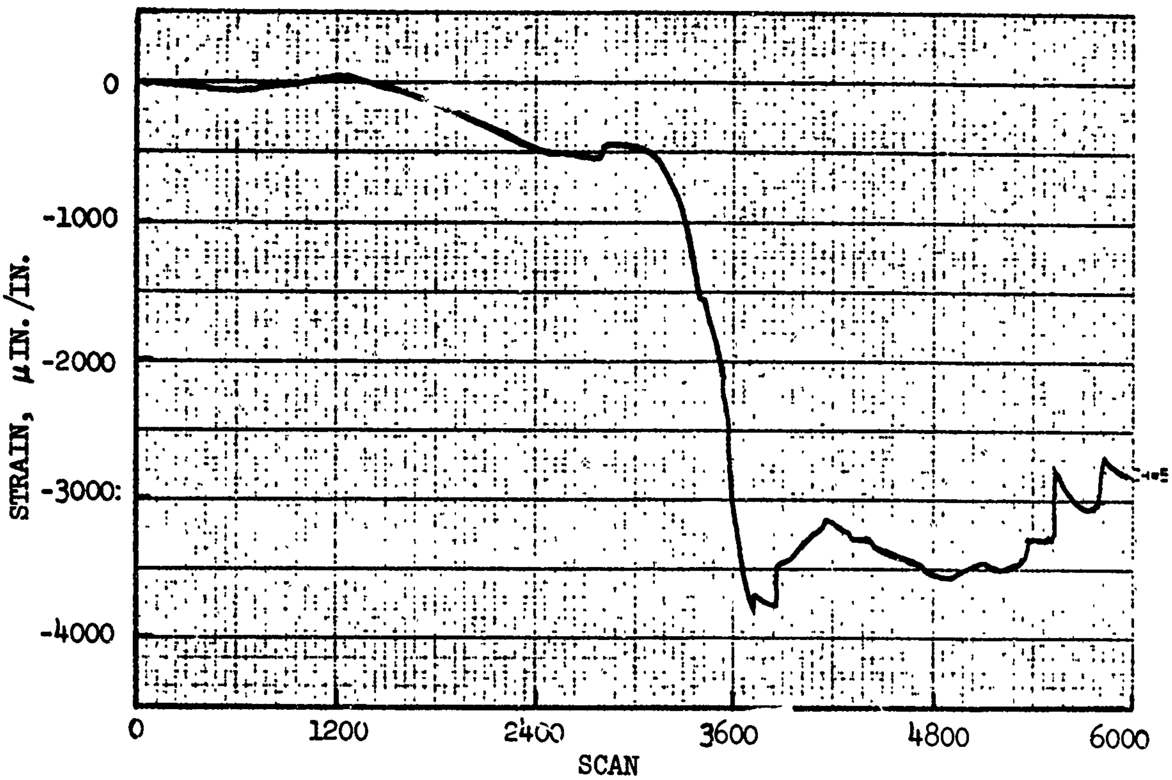


Figure 23. Strain Gage 1A Versus Scan, Test Specimen 3.

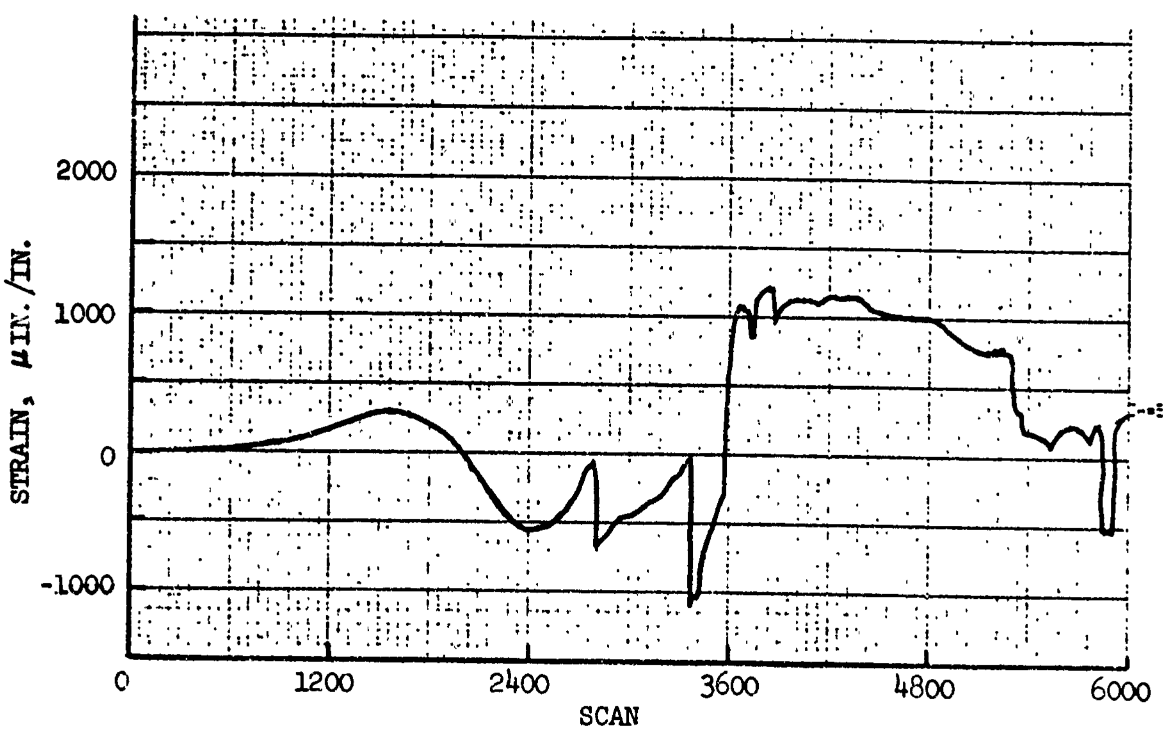


Figure 24. Strain Gage 1B Versus Scan, Test Specimen 3.

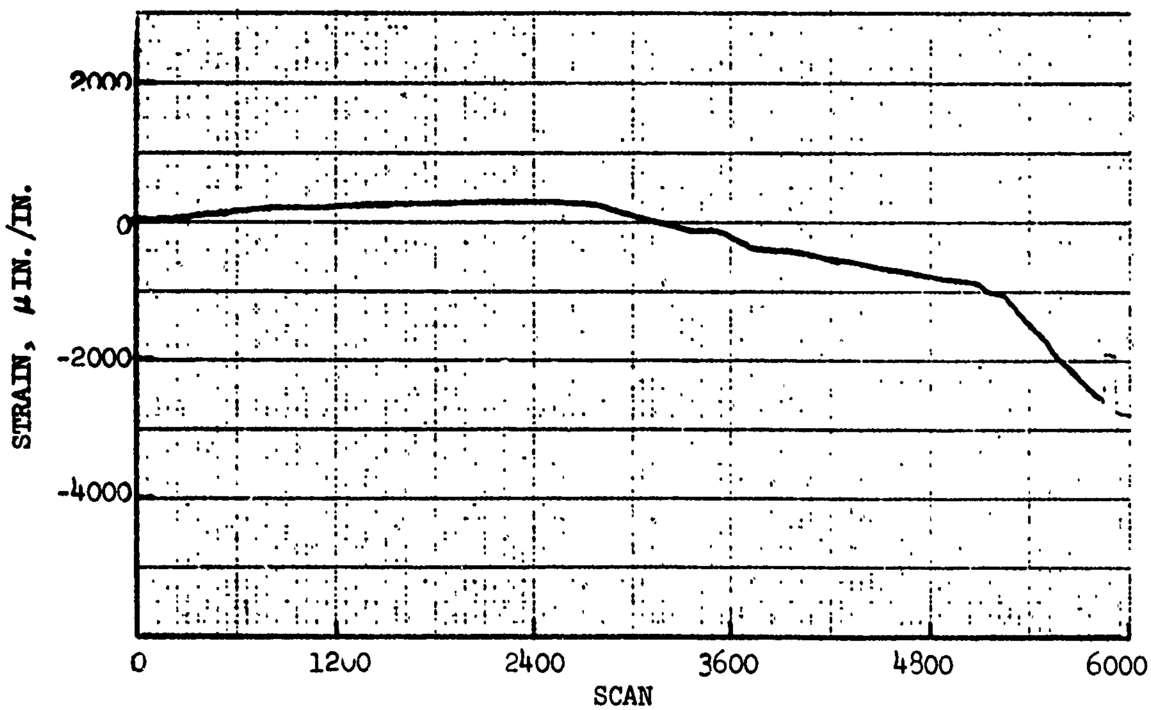


Figure 25. Strain Gage 2 Versus Scan Test Specimen 3.

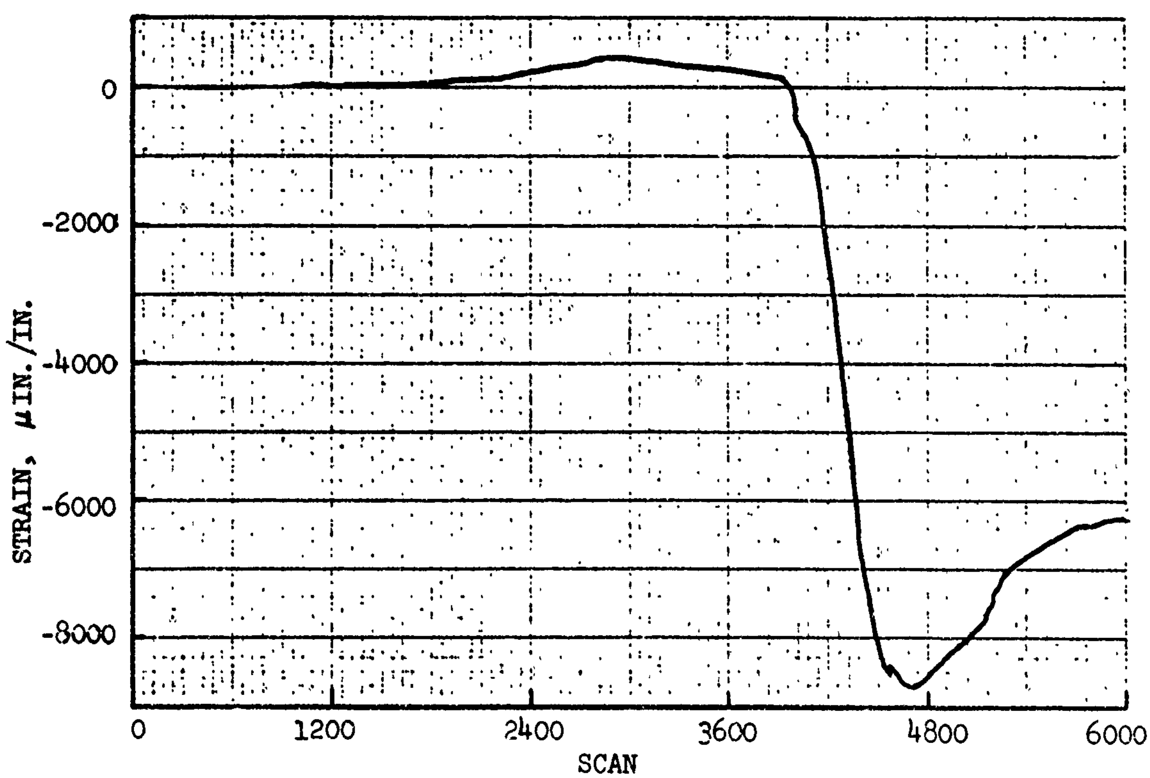


Figure 26. Strain Gage 3 Versus Scan, Test Specimen 3.

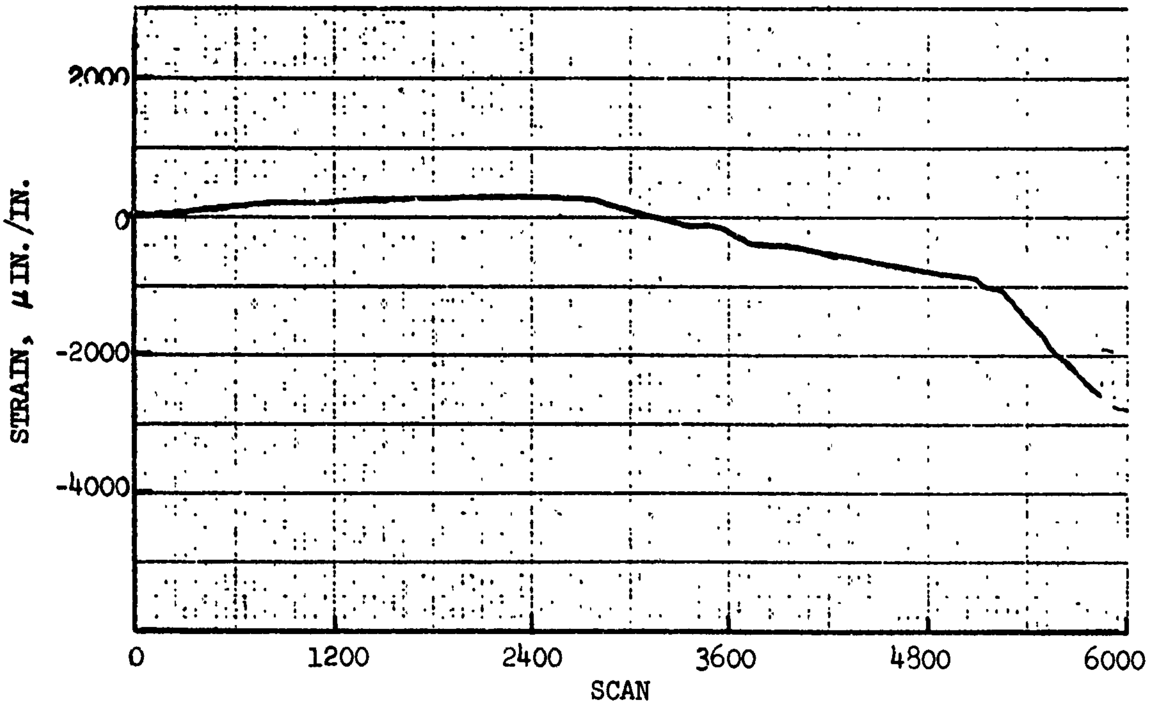


Figure 25. Strain Gage 2 Versus Scan, Test Specimen 3.

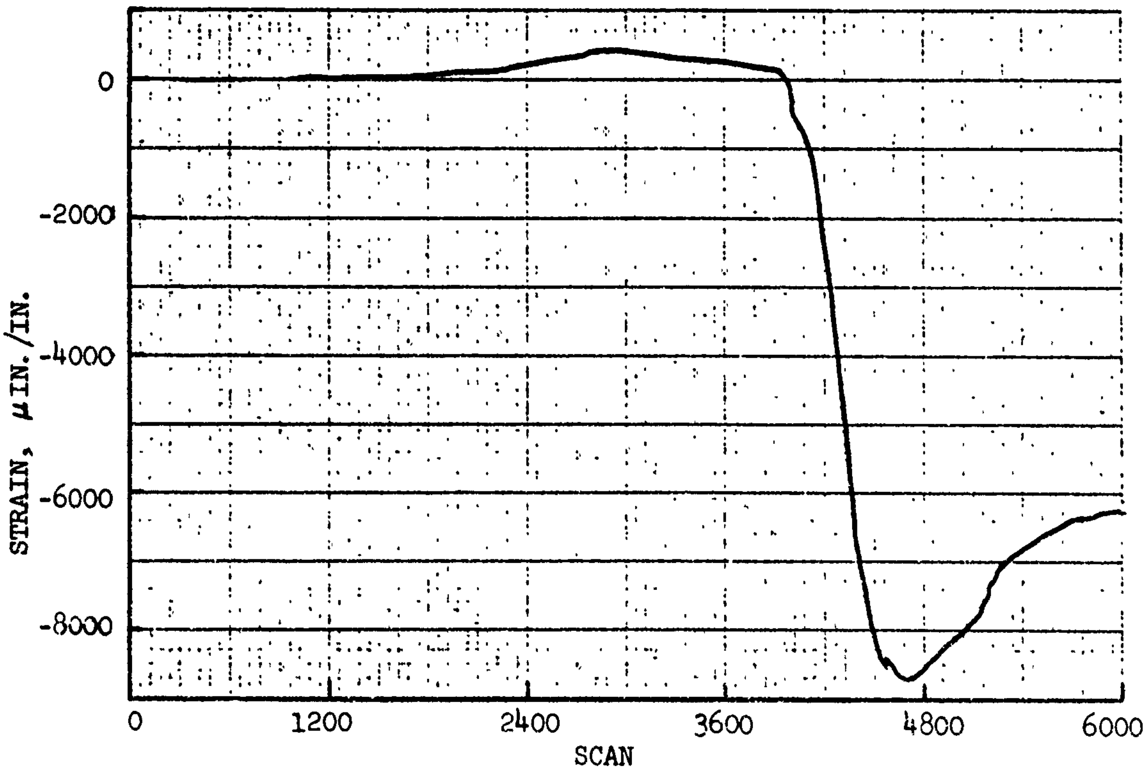


Figure 26. Strain Gage 3 Versus Scan, Test Specimen 3.

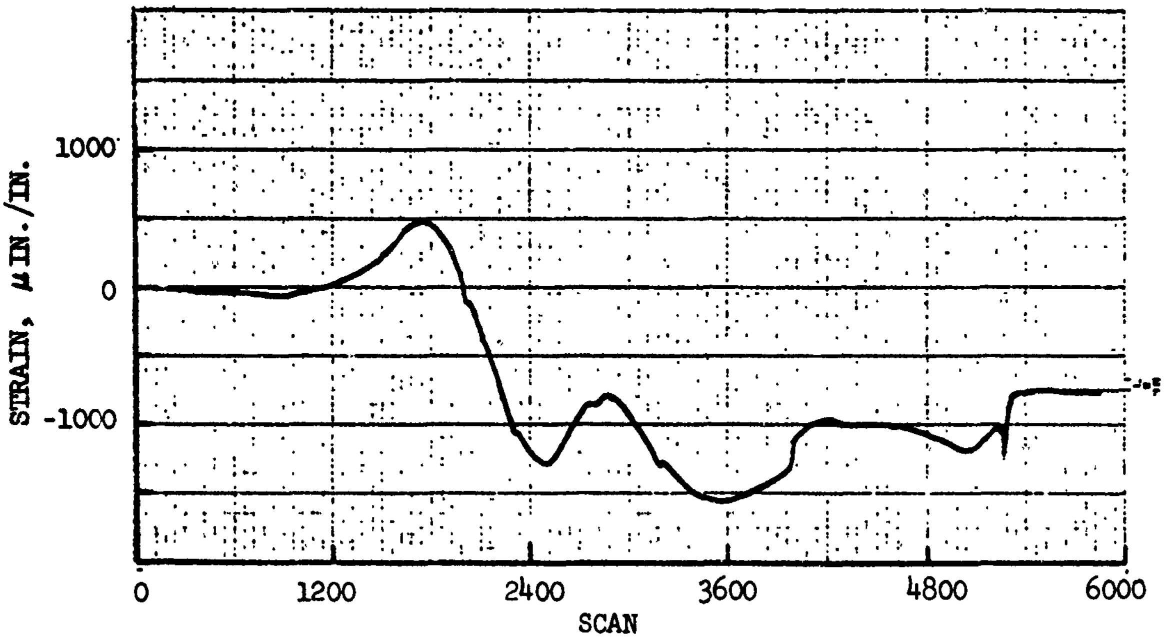


Figure 27. Strain Gage 4 Versus Scan, Test Specimen 3.

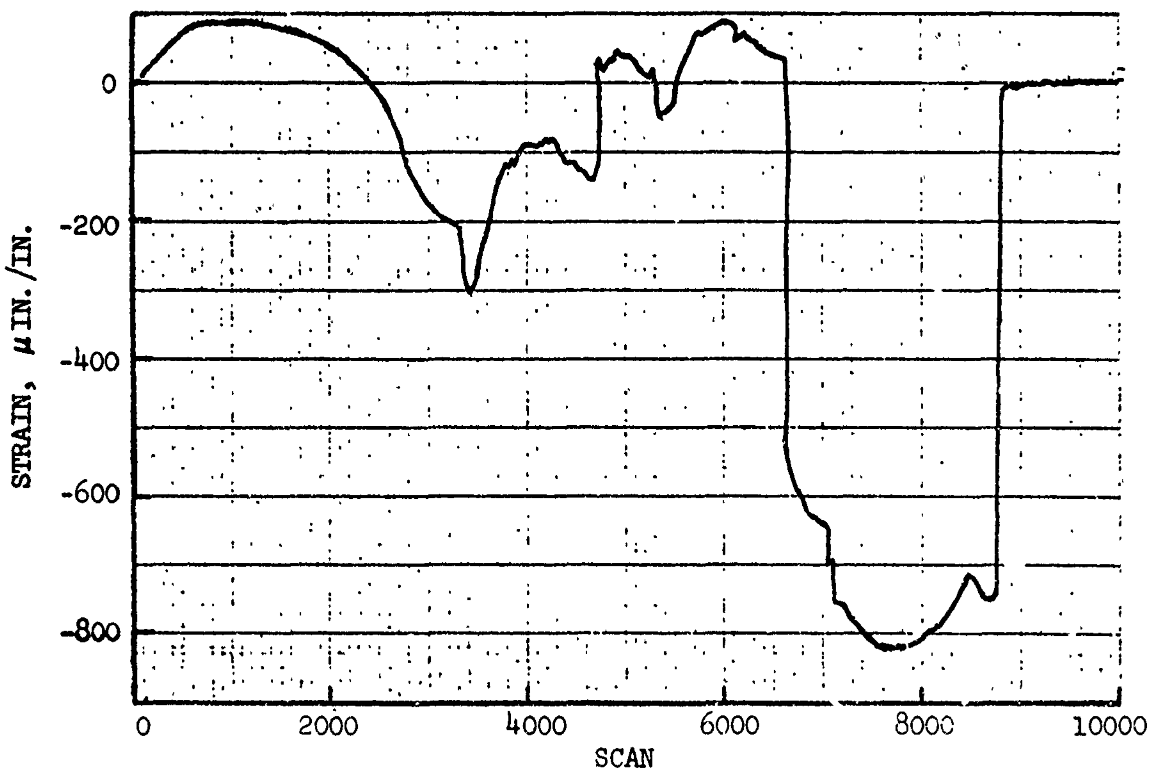


Figure 28. Strain Gage 5 Versus Scan, Test Specimen 3.

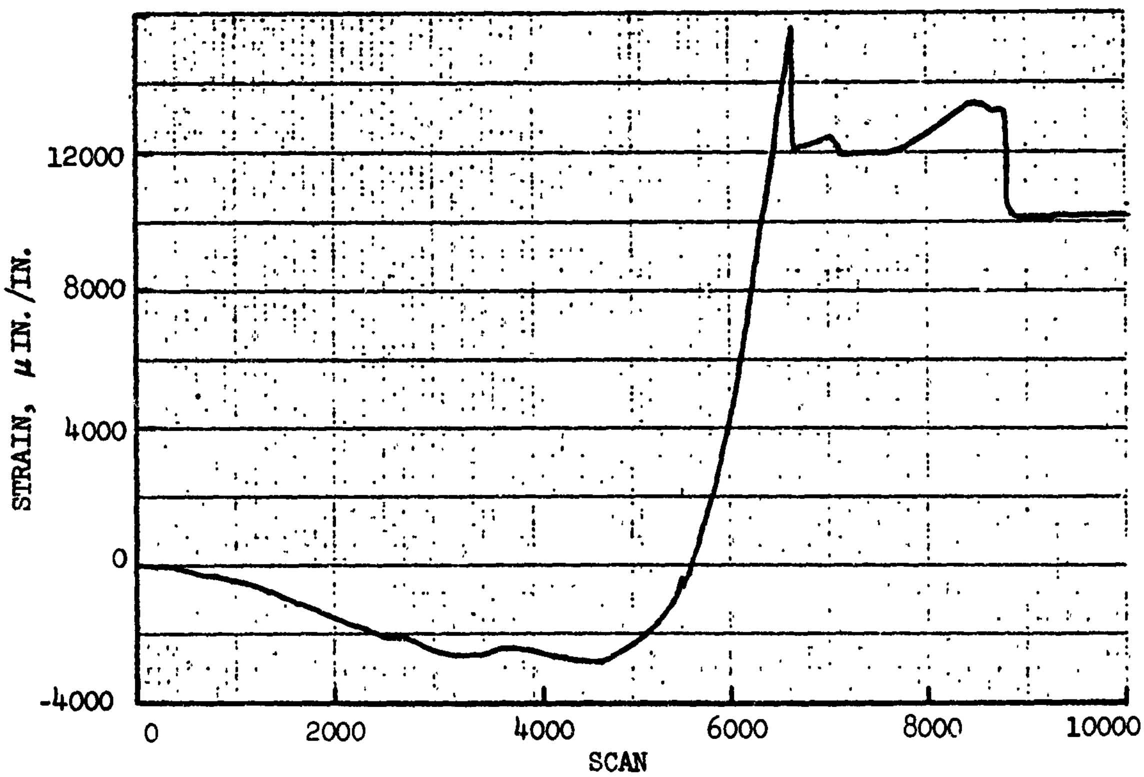


Figure 29. Strain Gage 6 Versus Scan, Test Specimen 3.

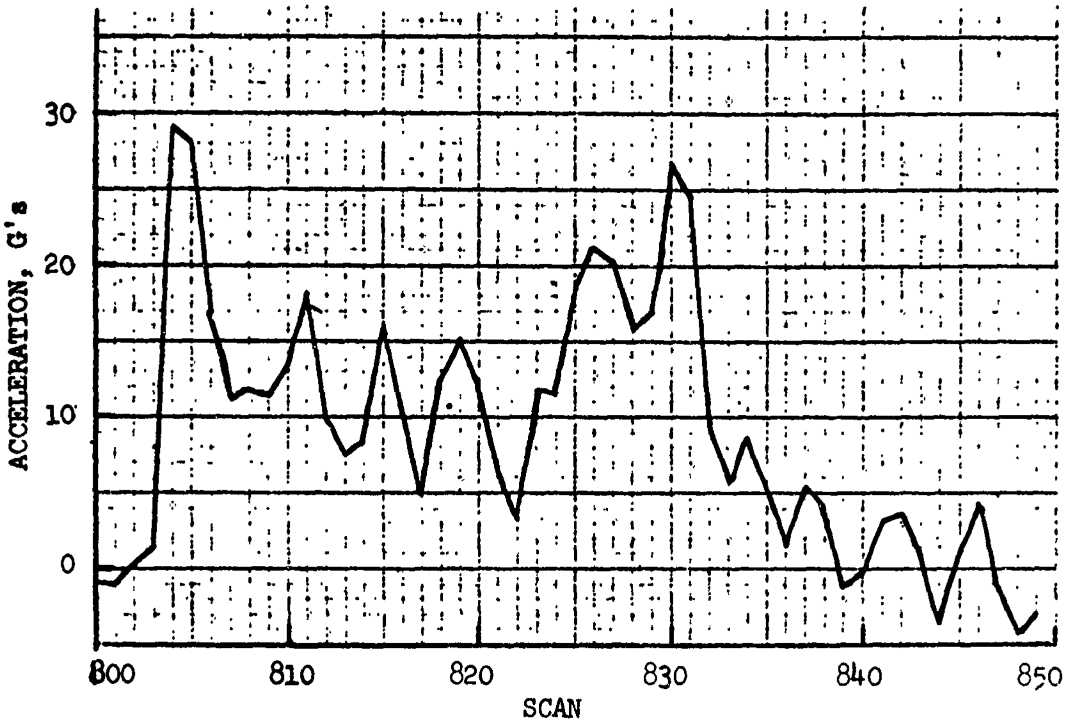


Figure 30. Acceleration Versus Scan, Test Specimen 4.

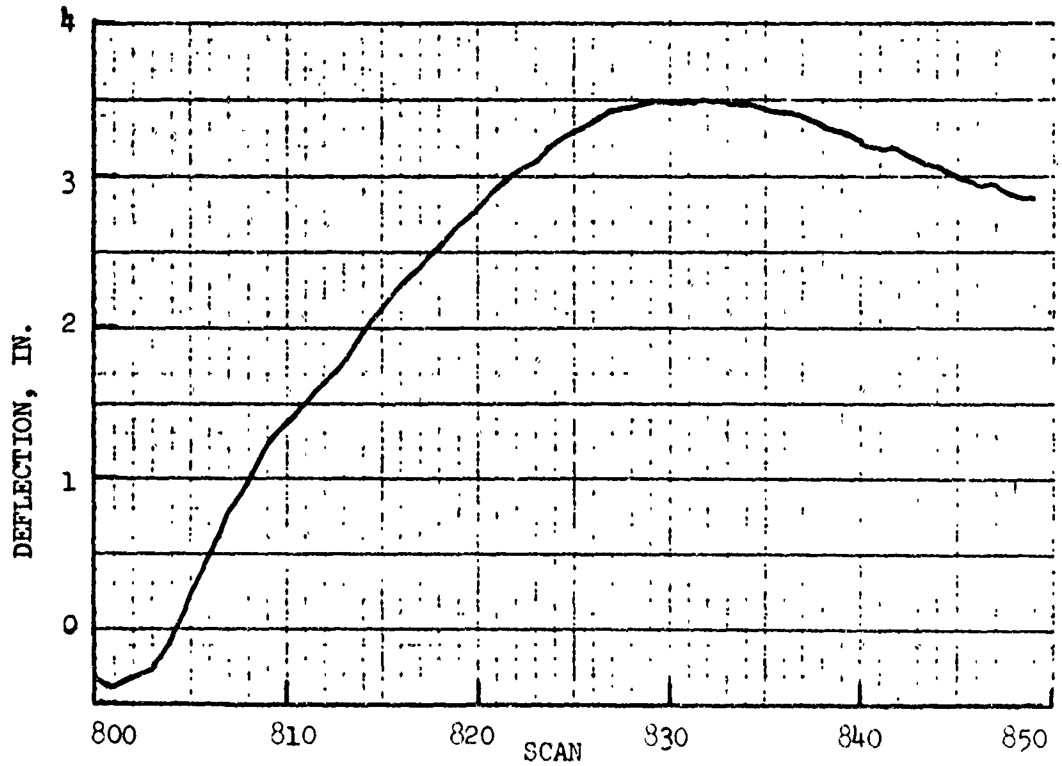


Figure 31. Deflection Versus Scan, Test Specimen 4.

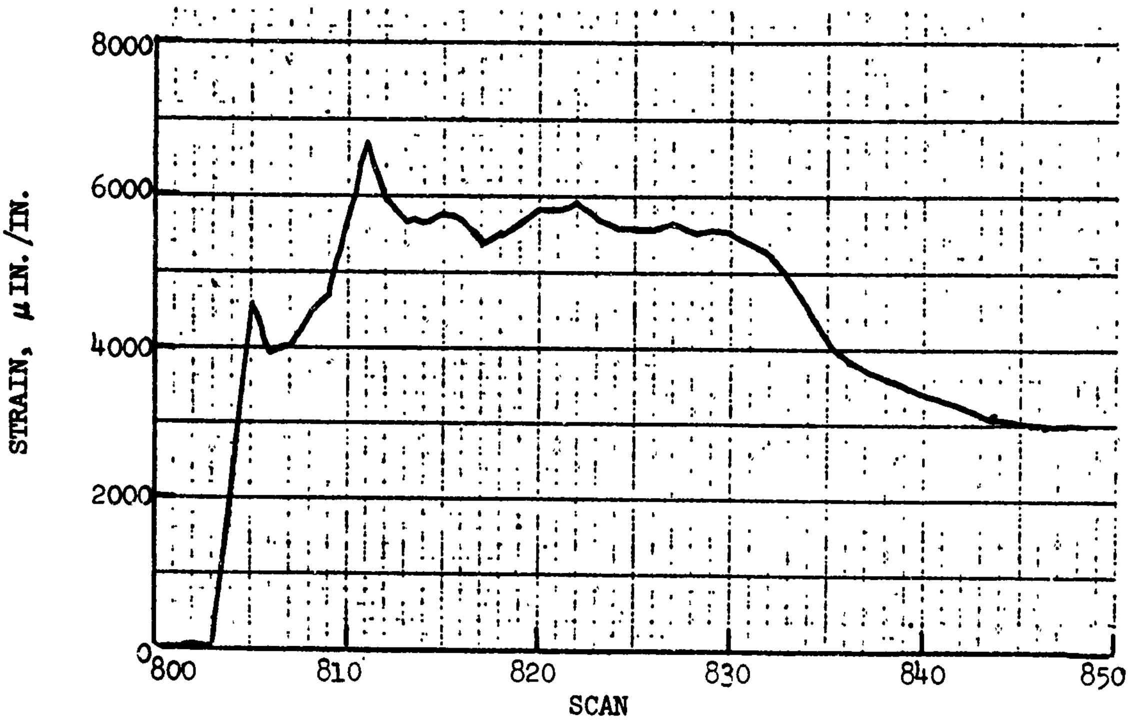


Figure 32. Strain Gage 1A Versus Scan, Test Specimen 4.

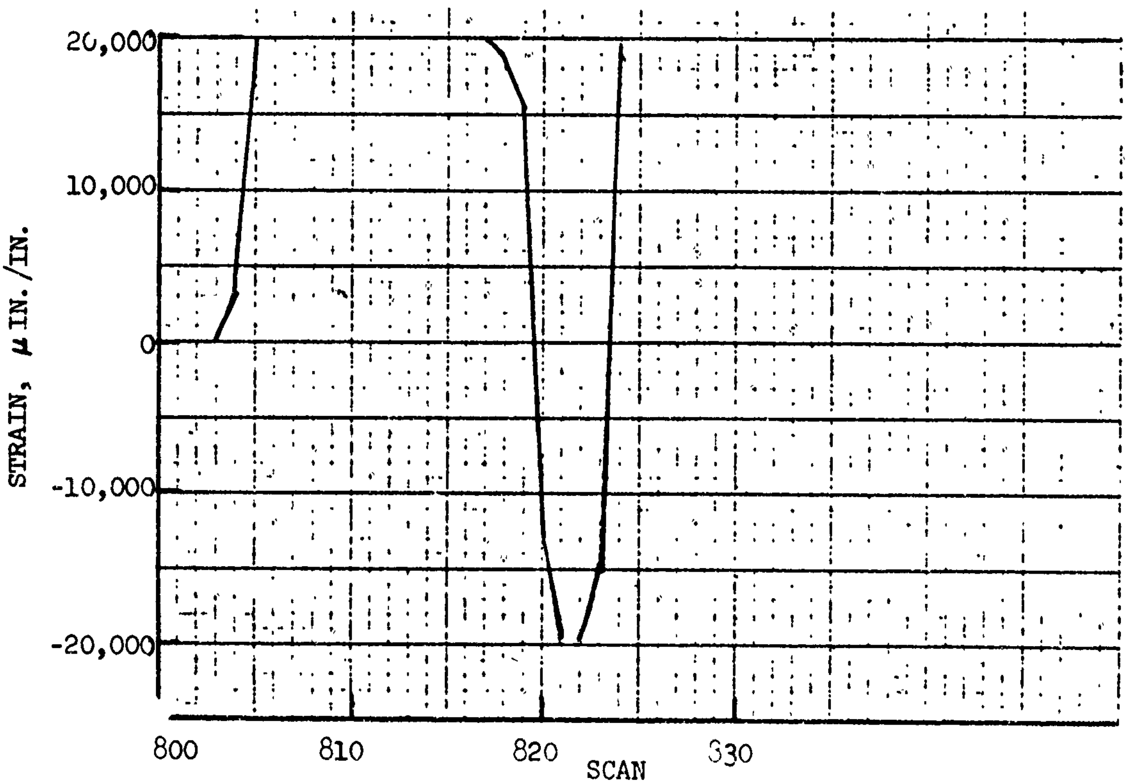


Figure 33. Strain Gage 1B Versus Scan, Test Specimen 4.

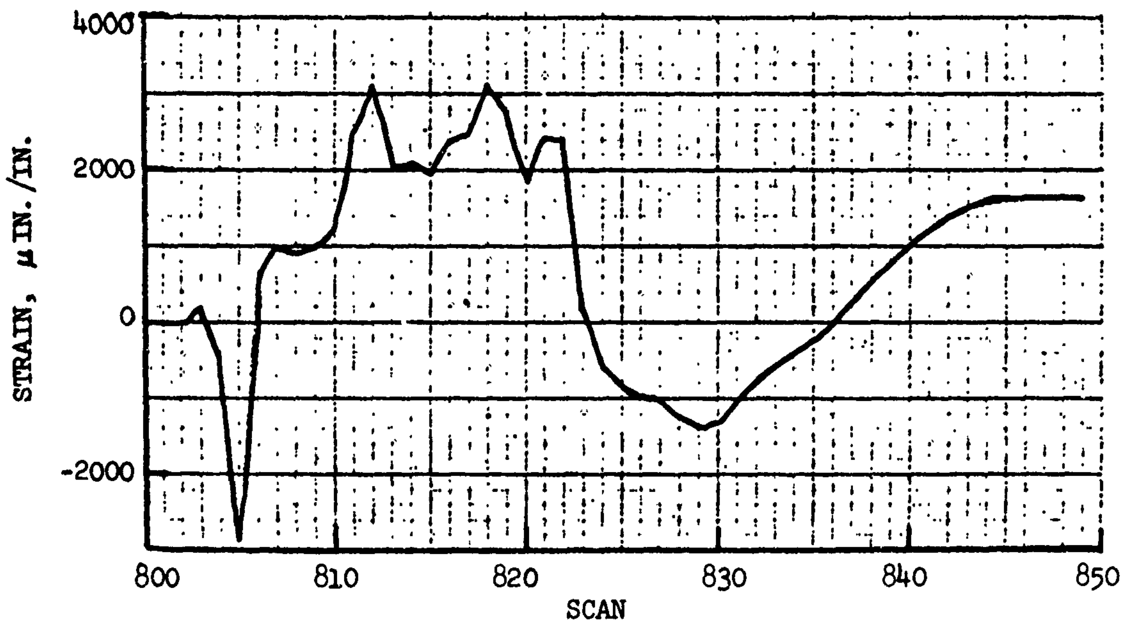


Figure 34. Strain Gage 2 Versus Scan, Test Specimen 4.

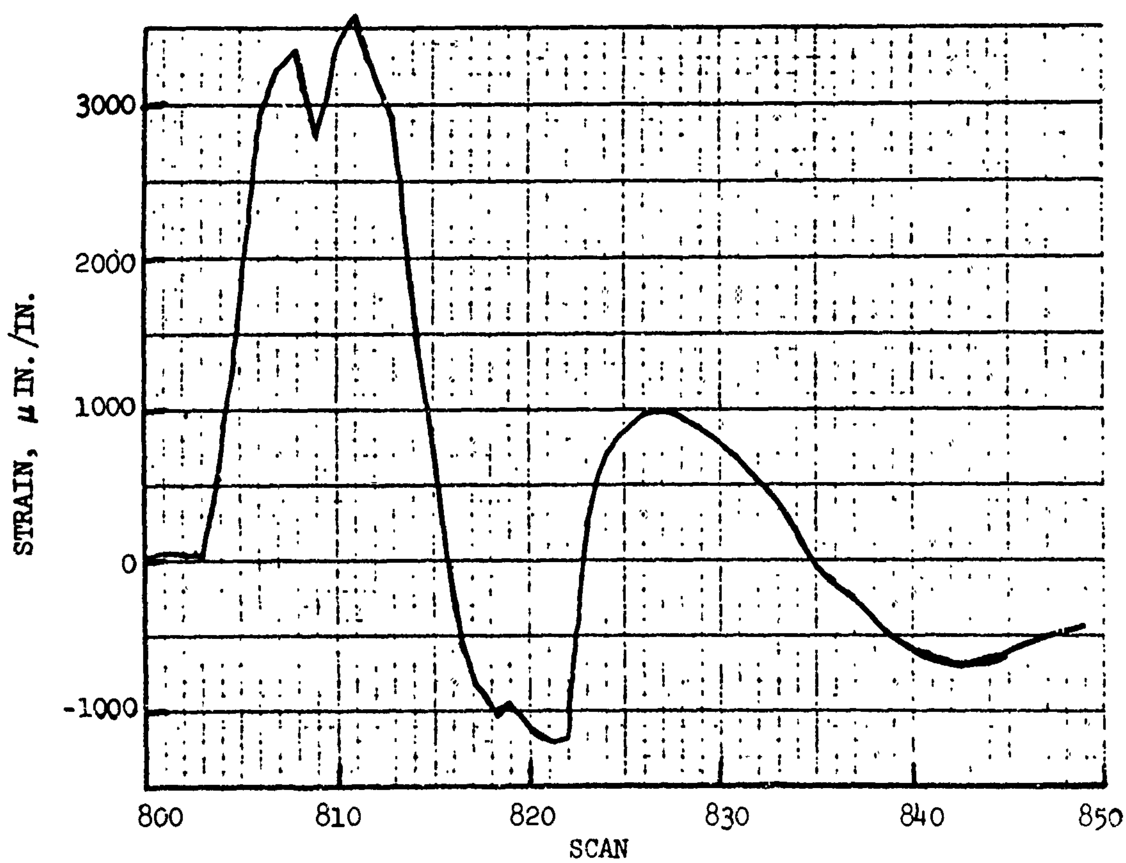


Figure 35. Strain Gage 3 Versus Scan, Test Specimen 4.

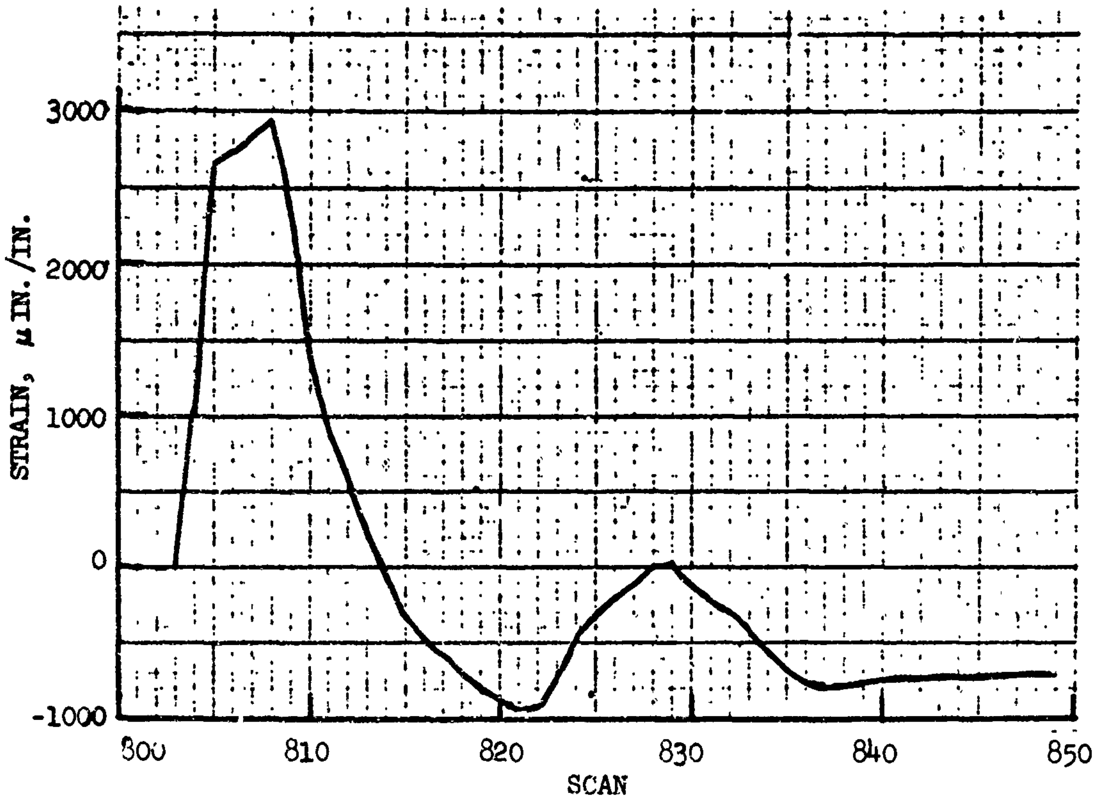


Figure 36. Strain Gage 4 Versus Scan, Test Specimen 4.

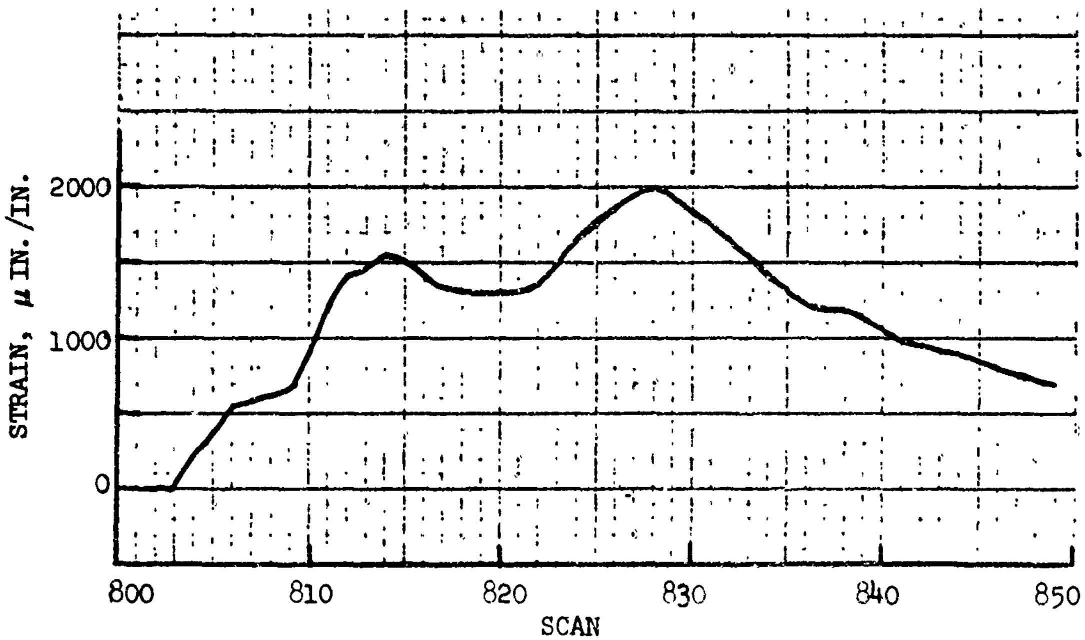


Figure 37. Strain Gage 5 Versus Scan, Test Specimen 4.

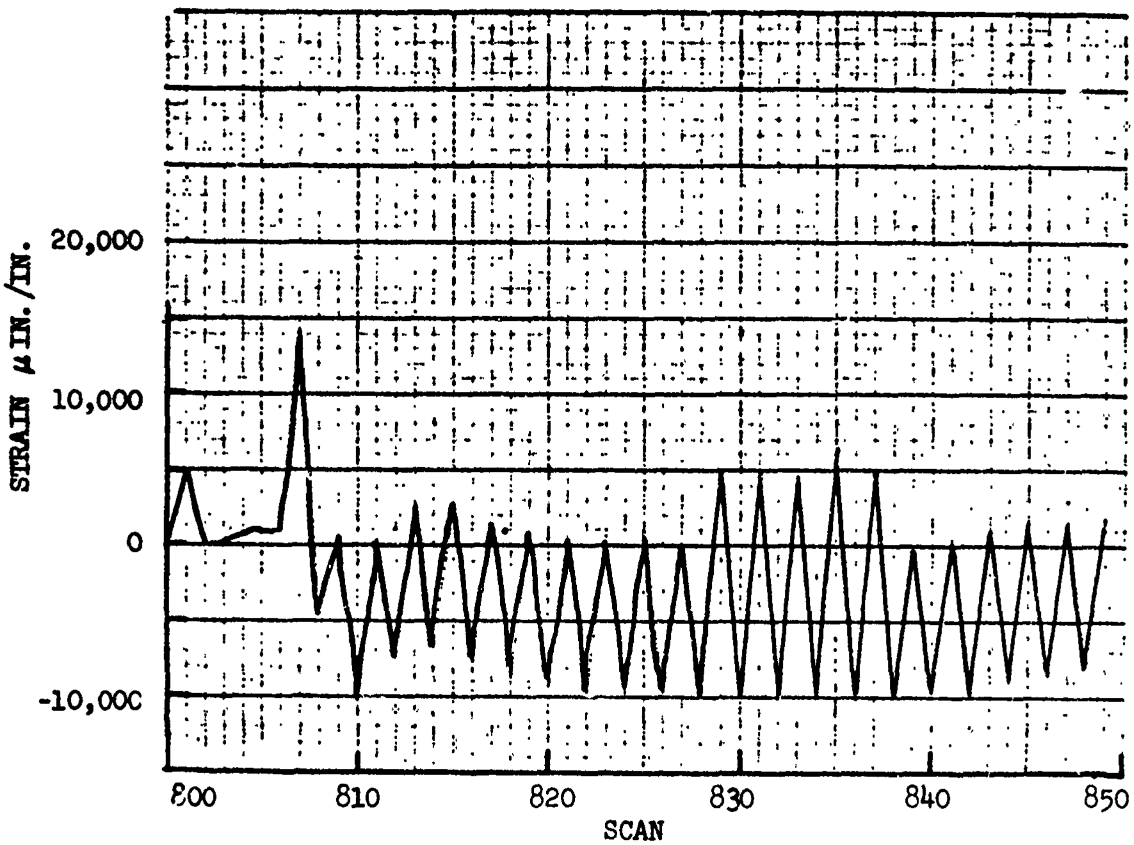


Figure 38. Strain Gage 6 Versus Scan, Test Specimen 4.

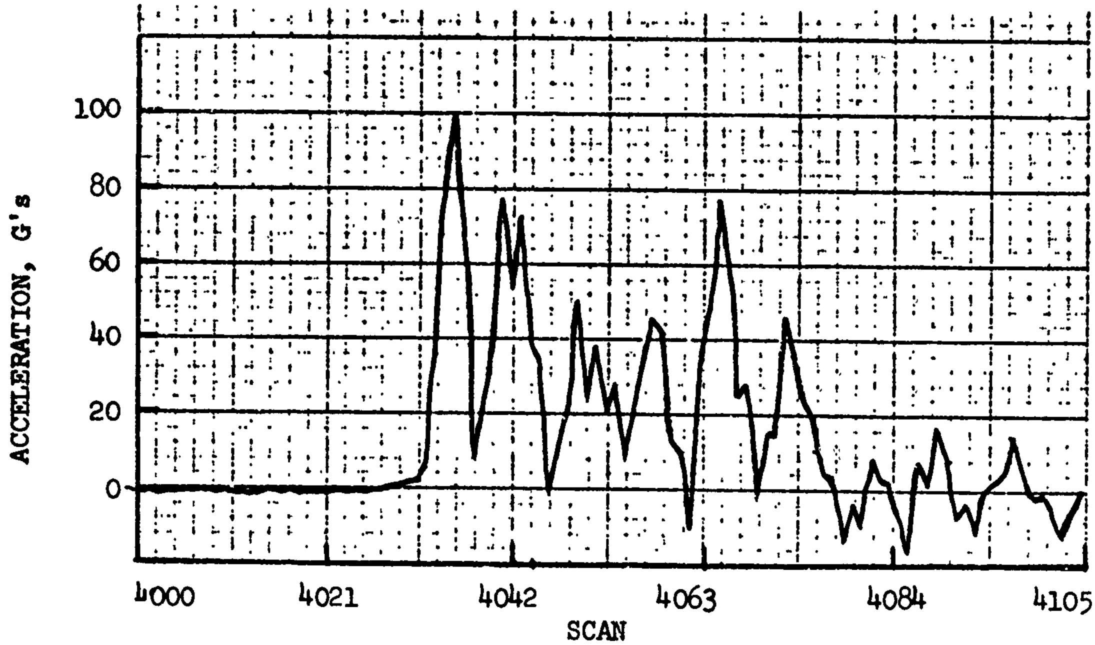


Figure 39. Acceleration Versus Scan, Test Specimen 5.

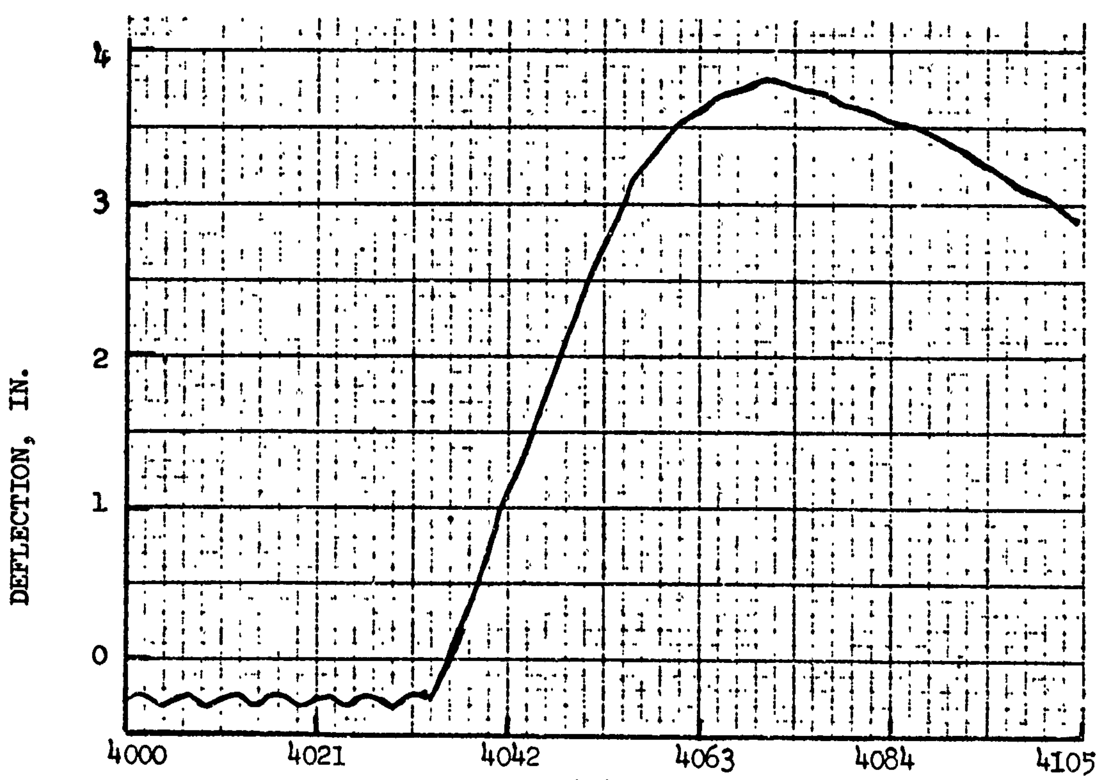


Figure 40. Deflection Versus Scan, Test Specimen 5.

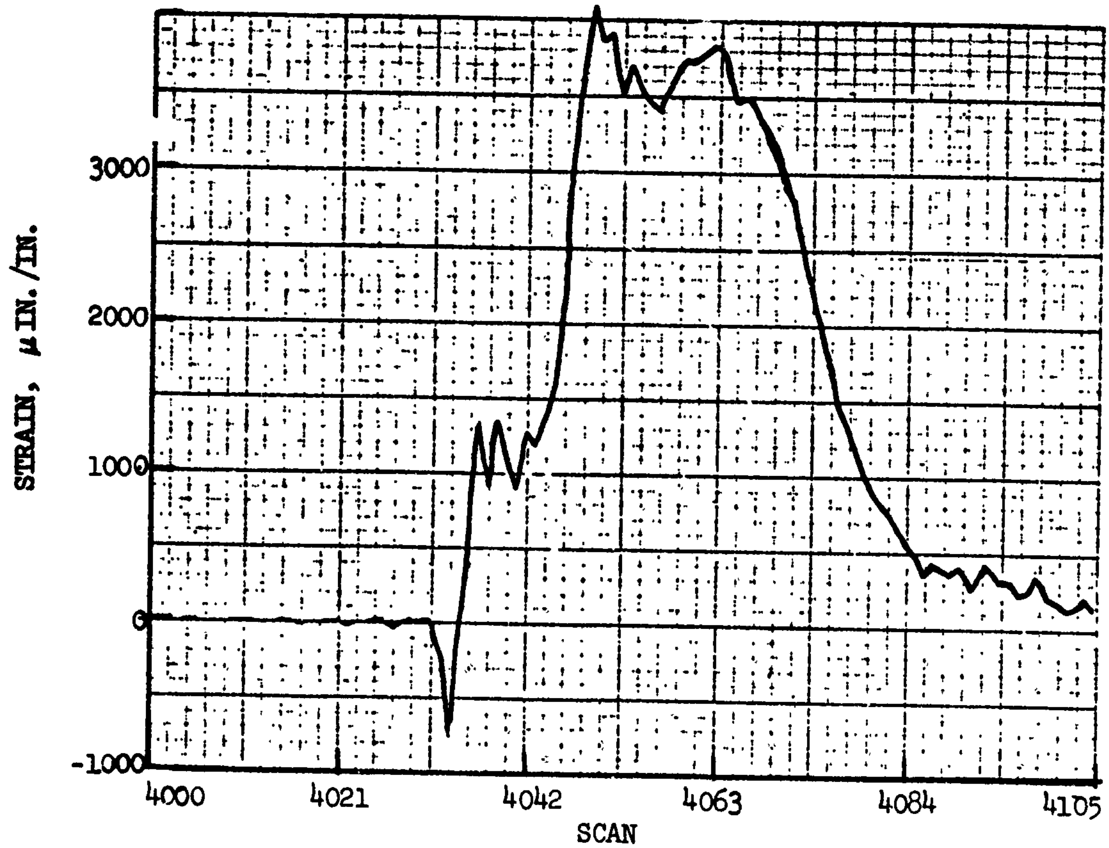


Figure 41. Strain Gage 1A Versus Scan, Test Specimen 5.

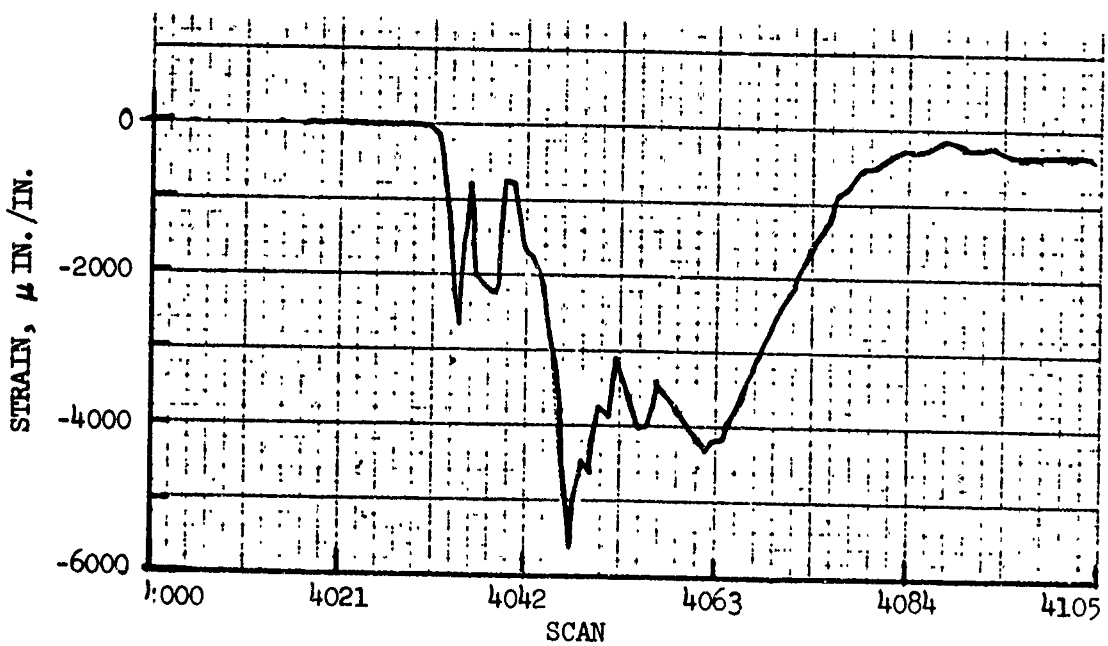


Figure 42. Strain Gage 1B Versus Scan, Test Specimen 5.

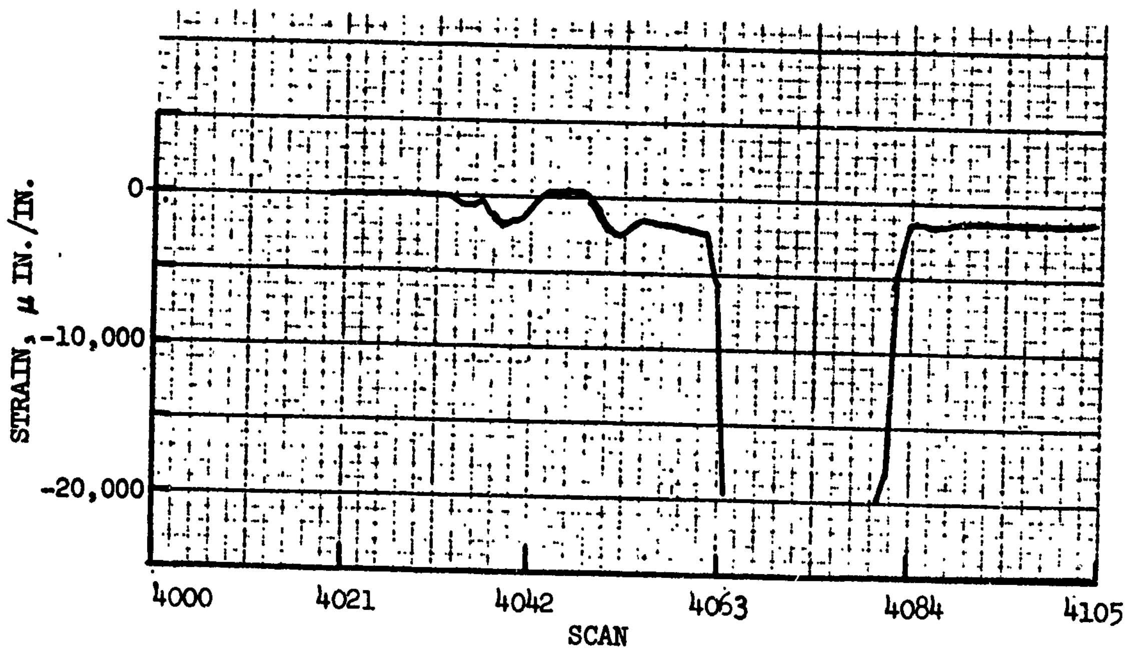


Figure 43. Strain Gage 2 Versus Scan, Test Specimen 5.

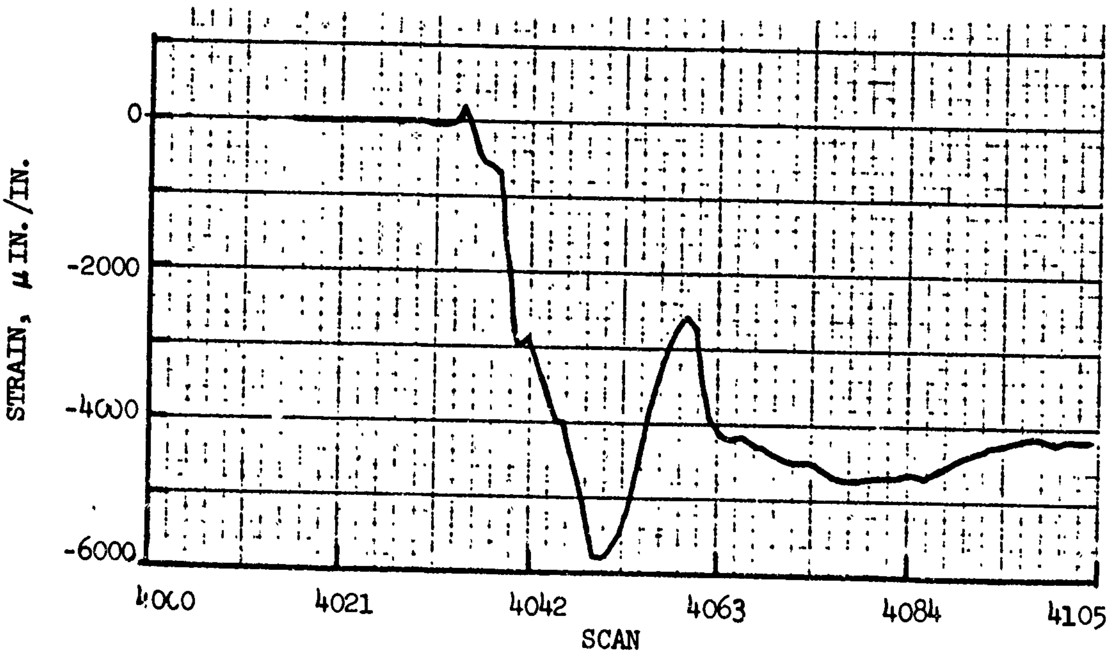


Figure 44. Strain Gage 4 Versus Scan, Test Specimen 5.

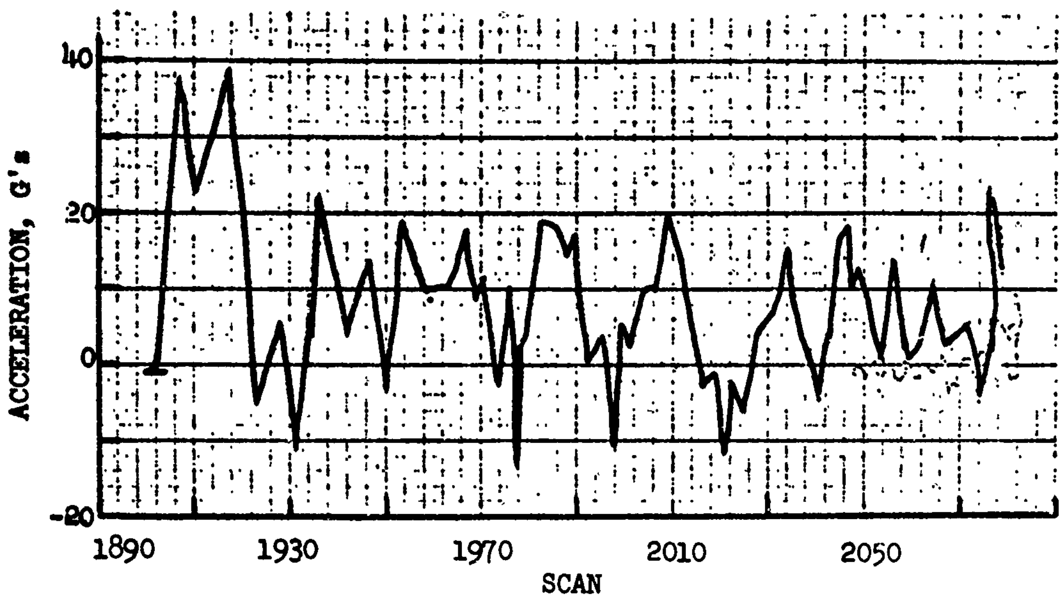


Figure 45. Acceleration Versus Scan, Test Specimen 6.

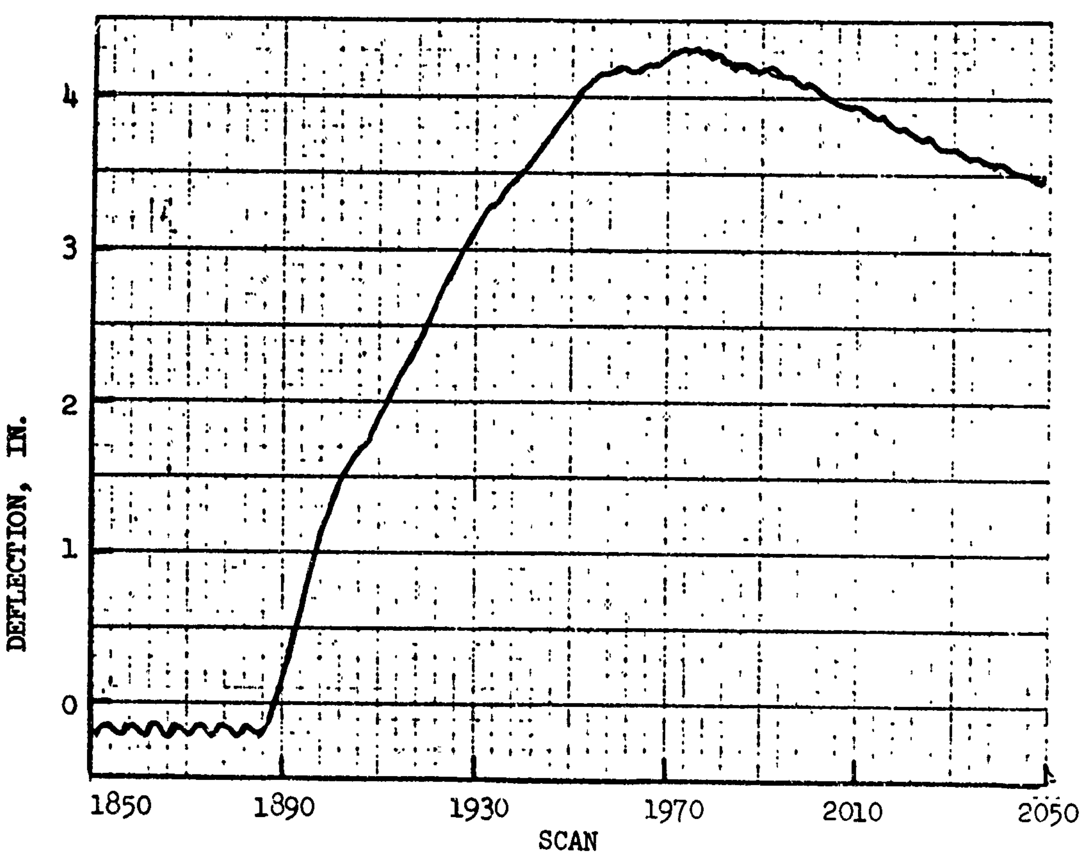


Figure 46. Deflection Versus Scan, Test Specimen 6.

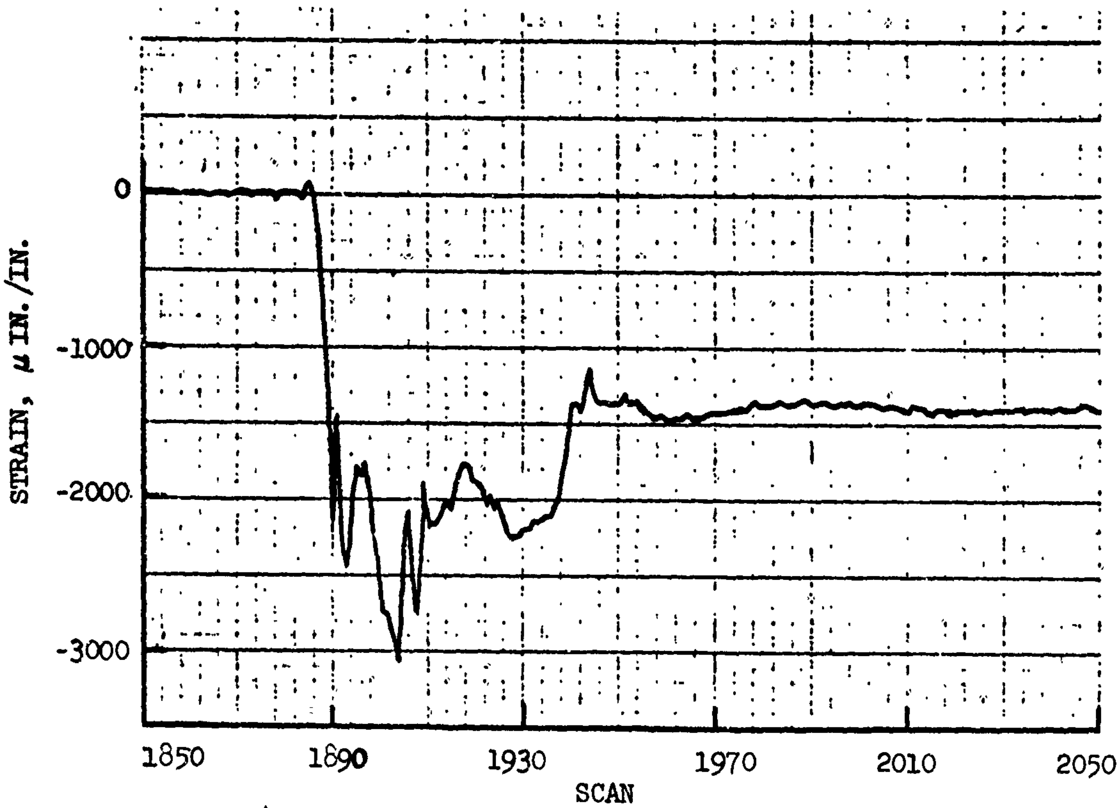


Figure 47. Strain Gage 1A Versus Scan, Test Specimen 6.

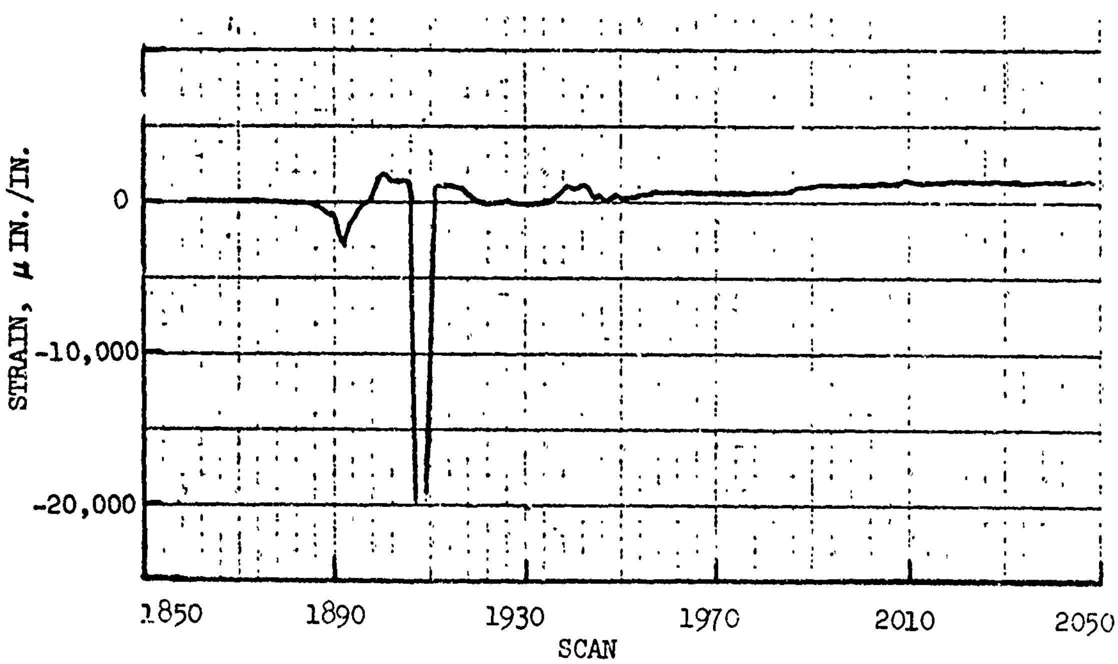


Figure 48. Strain Gage 1B Versus Scan, Test Specimen 6.

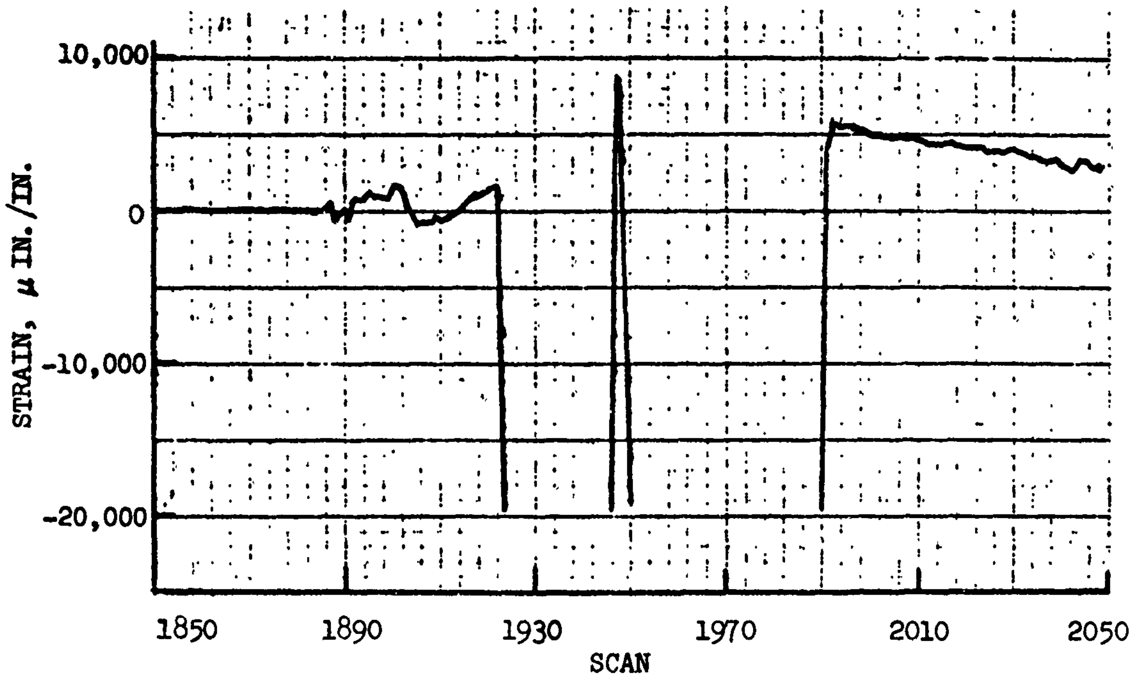


Figure 49. Strain Gage 2 Versus Scan, Test Specimen 6.

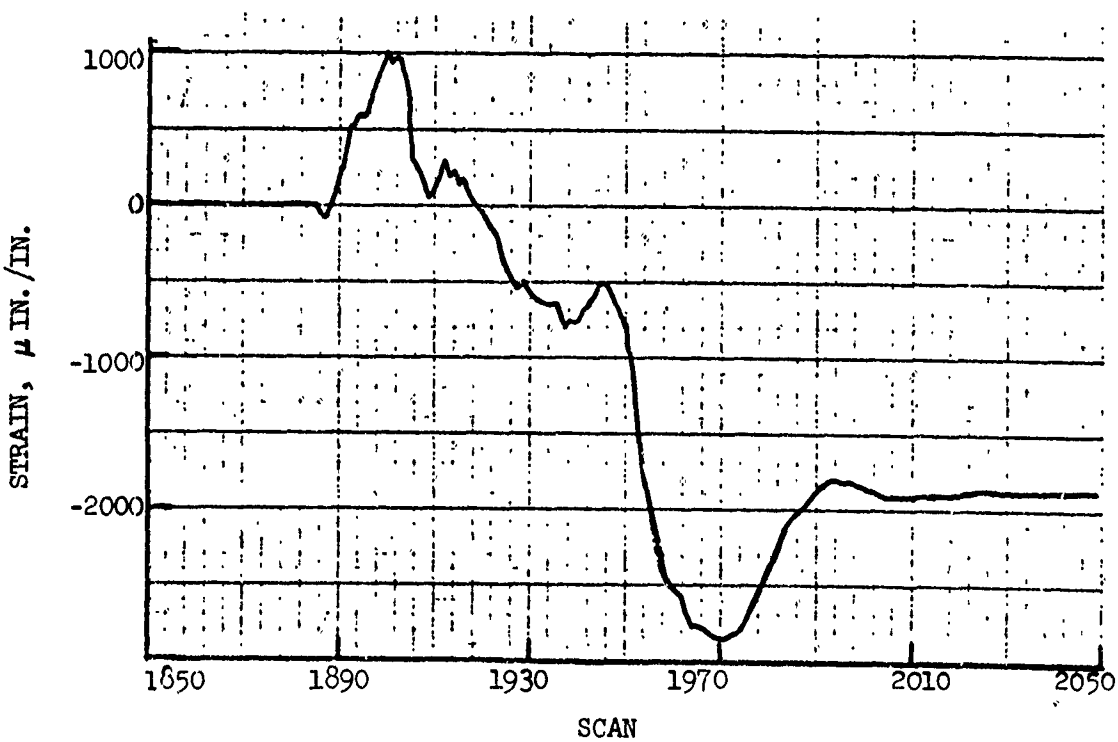


Figure 50. Strain Gage 6 Versus Scan, Test Specimen 6.

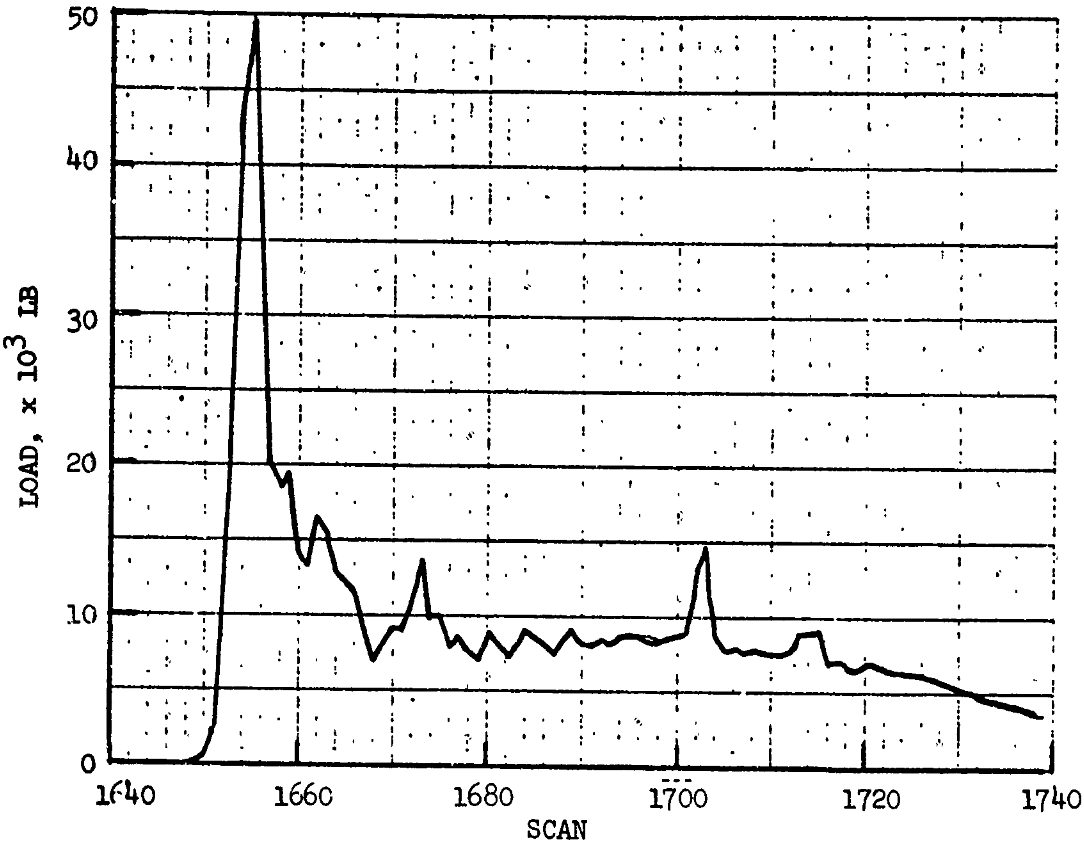


Figure 51. Load Cell (North) Versus Scan, Test Specimen 7.

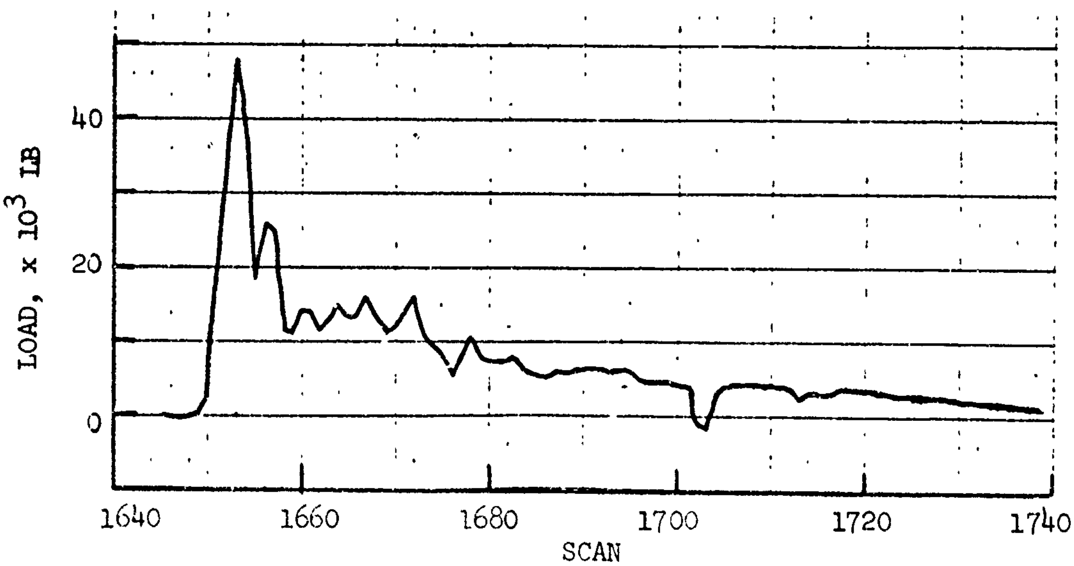


Figure 52. Load Cell (South) Versus Scan, Test Specimen 7.

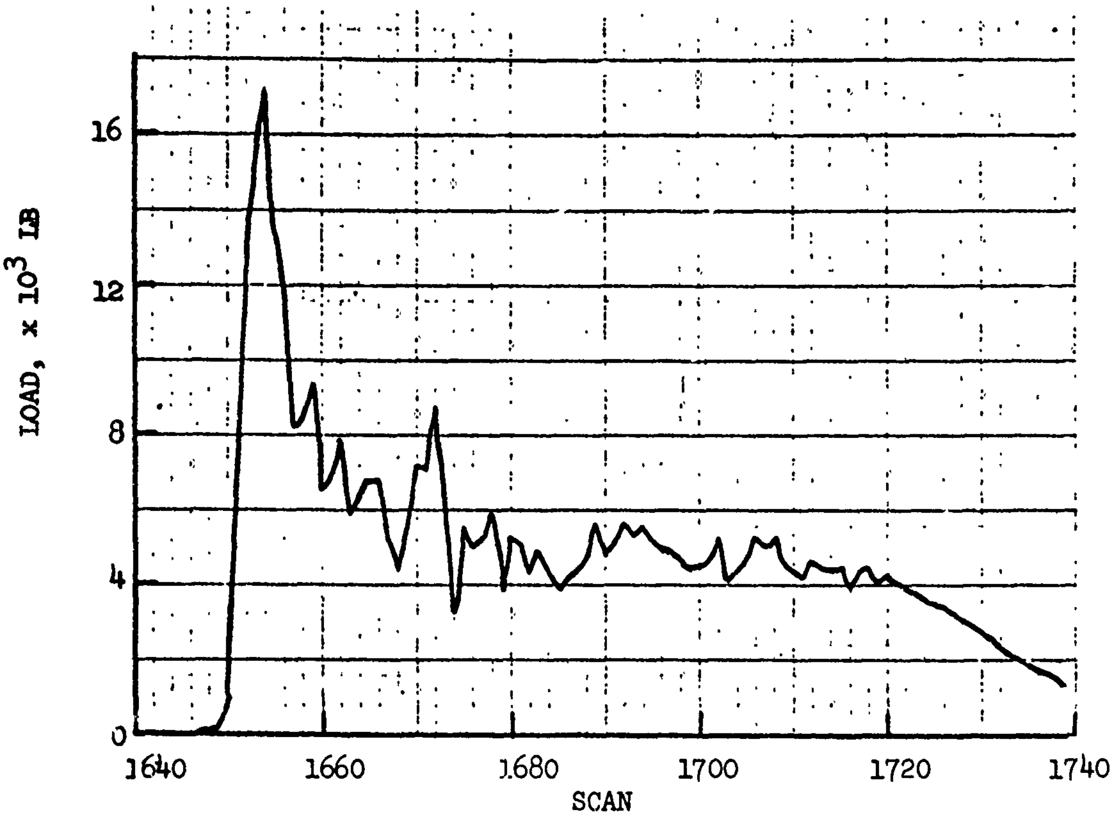


Figure 53. Load Cell (East) Versus Scan, Test Specimen 7.

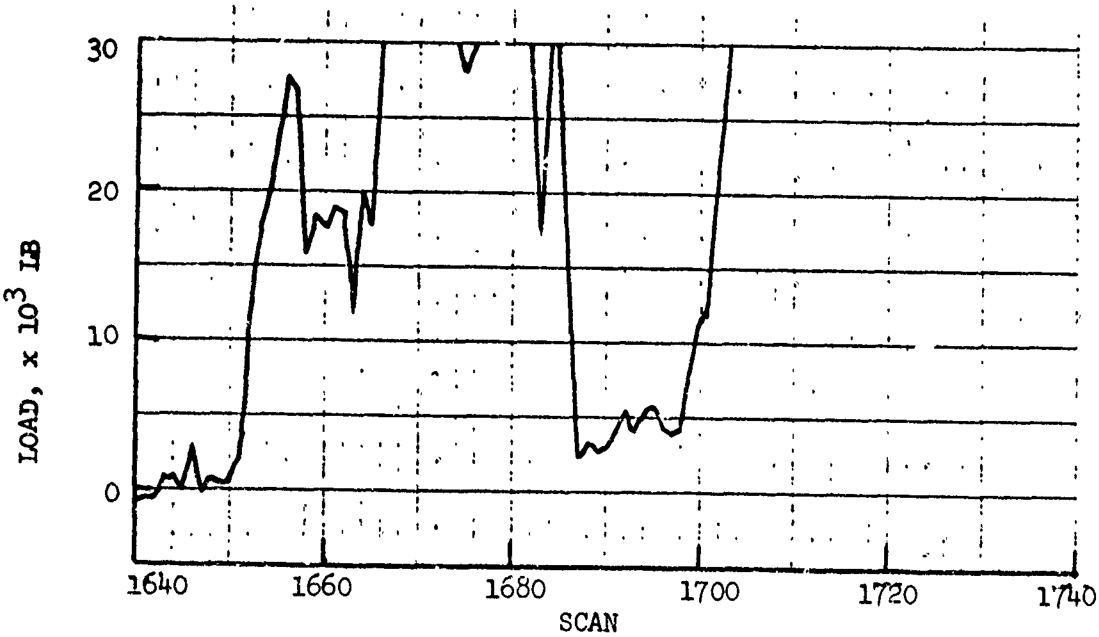


Figure 54. Load Cell (West) Versus Scan, Test Specimen 7.

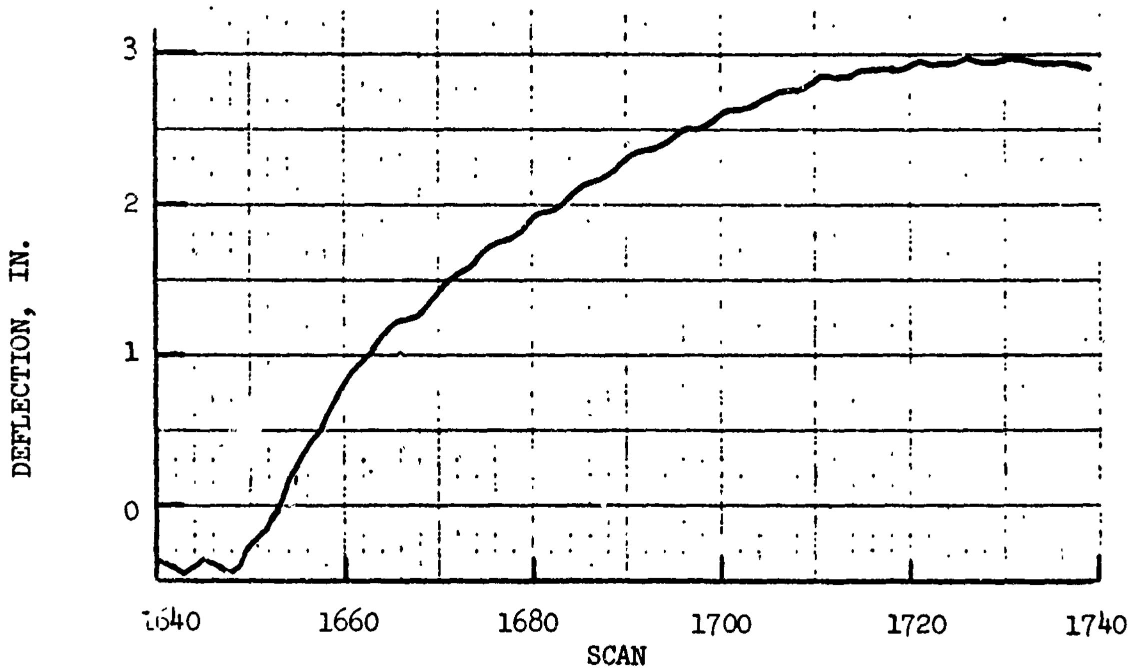


Figure 55. Deflection Versus Scan, Test Specimen 7.

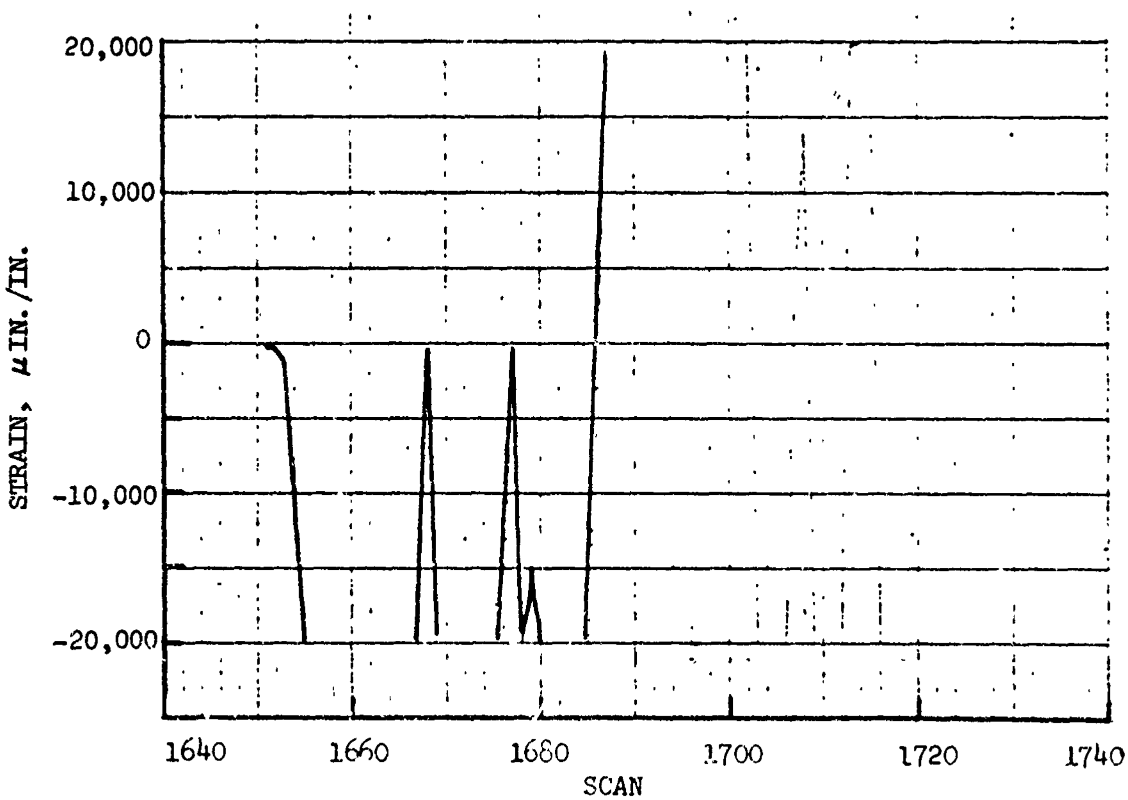


Figure 56. Strain Gage 1A Versus Scan, Test Specimen 7.

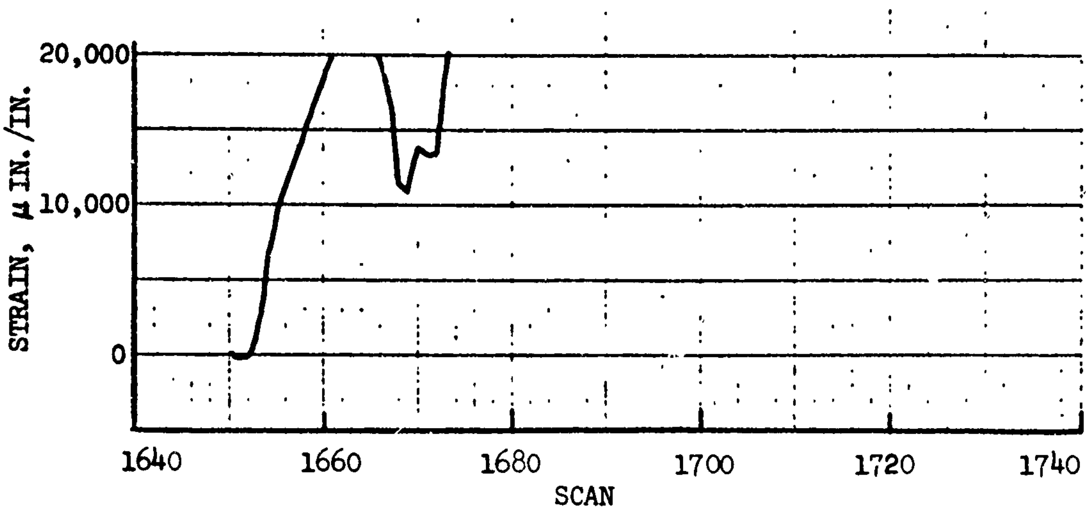


Figure 57. Strain Gage 1B Versus Scan, Test Specimen 7.

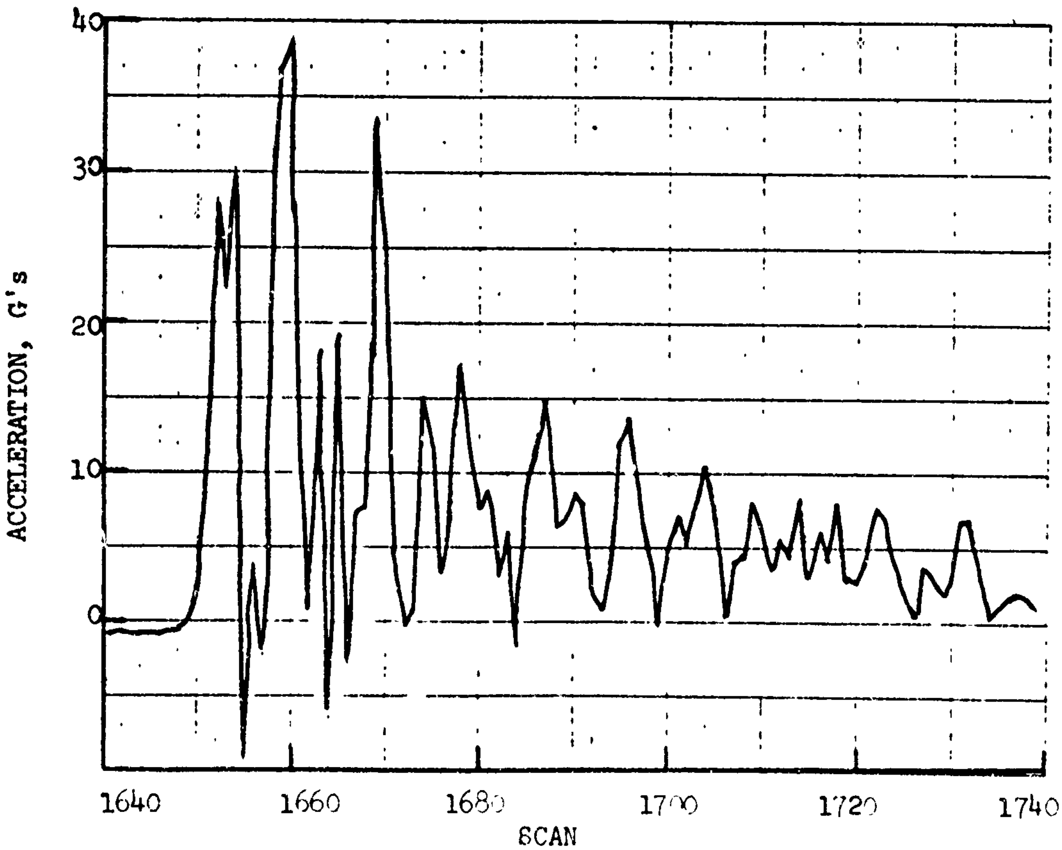


Figure 5?. Acceleration (East) Versus Scan, Test Specimen 7.

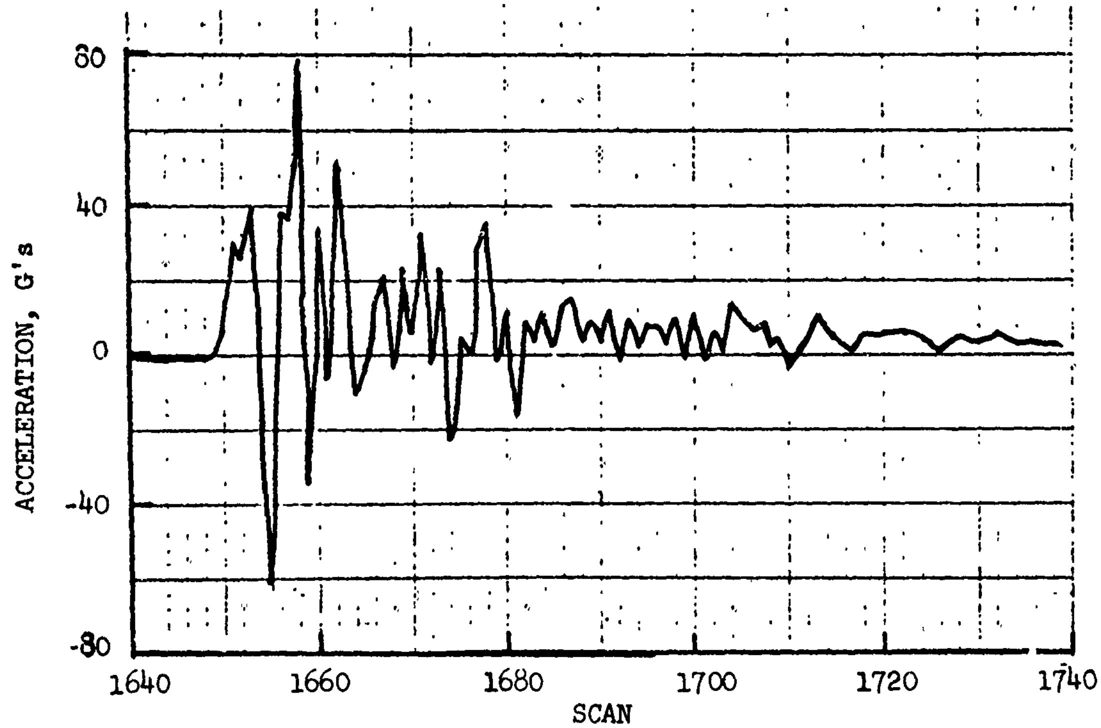


Figure 59. Acceleration (Center) Versus Scan, Test Specimen 7

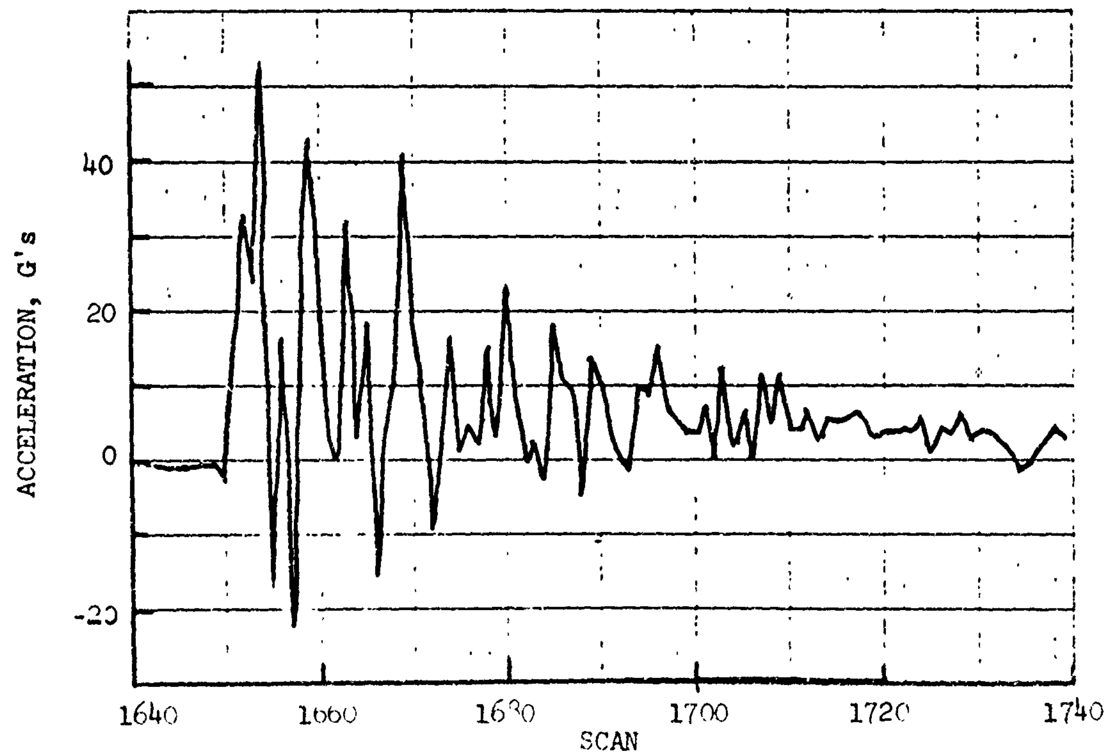


Figure 60. Acceleration (West) Versus Scan, Test Specimen 7.

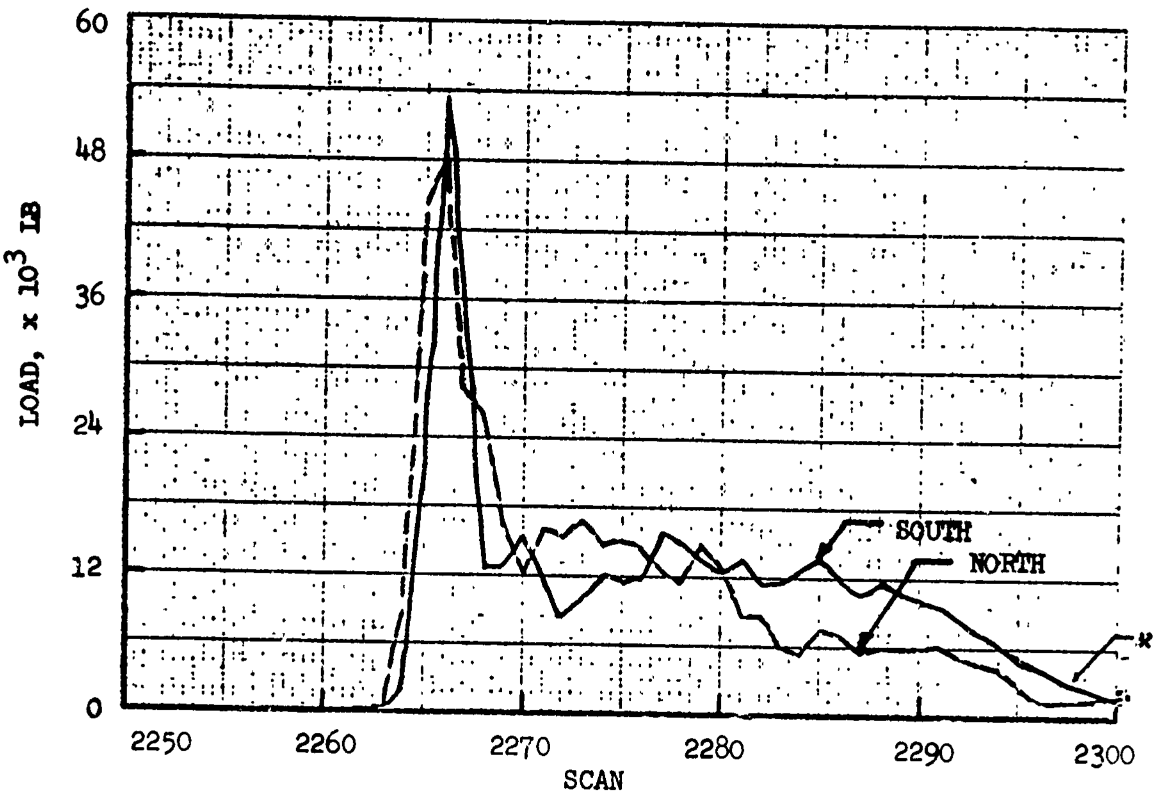


Figure 61. Load Cells (North and South) Versus Scan, Test Specimen 8.

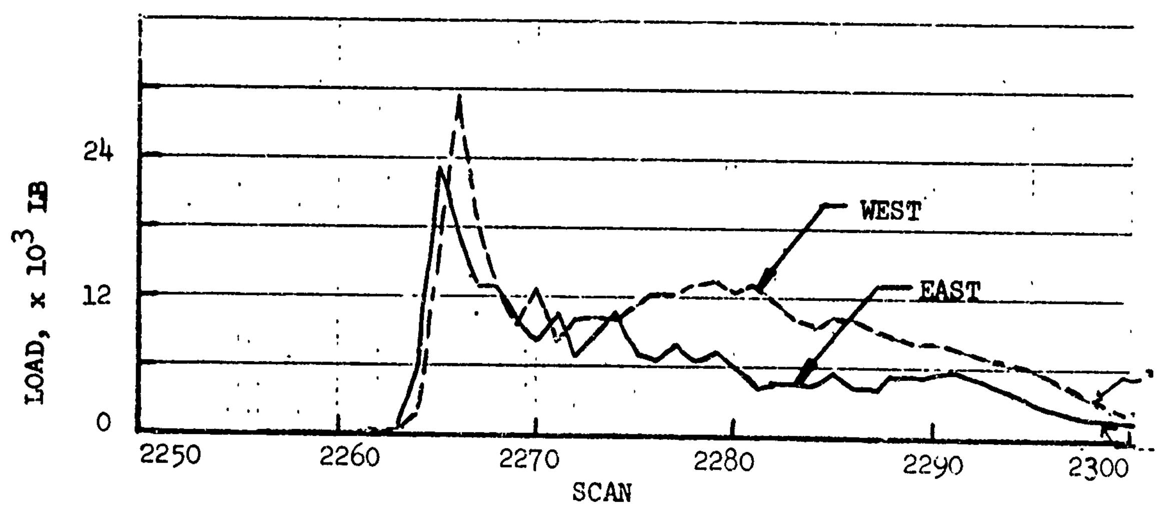


Figure 62. Load Cells (East and West) Versus Scan, Test Specimen 8.

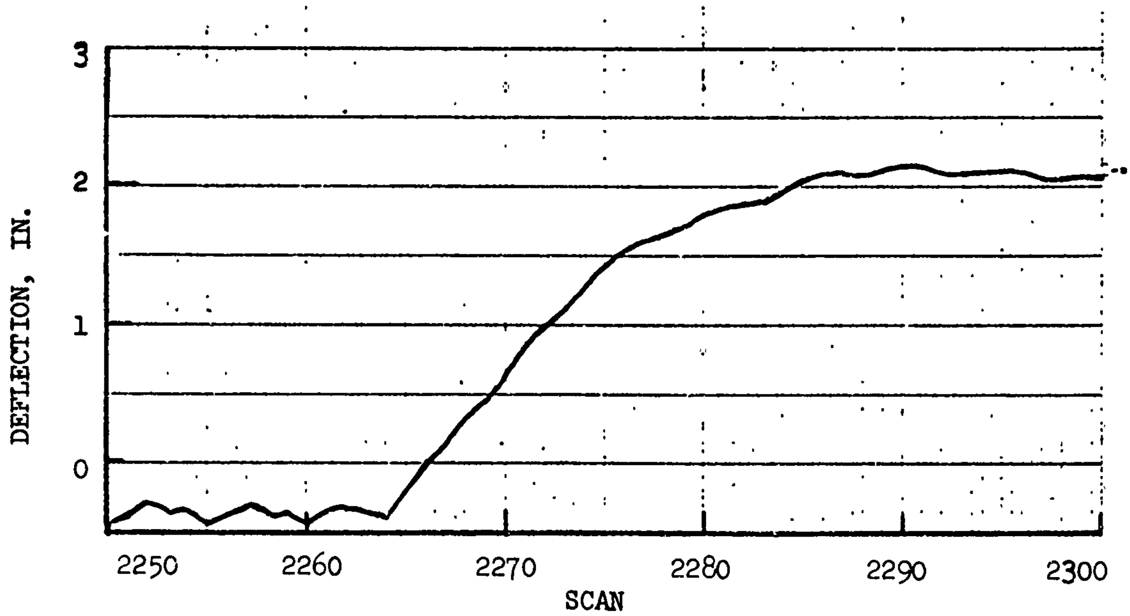


Figure 63. Deflection Versus Scan, Test Specimen 8.

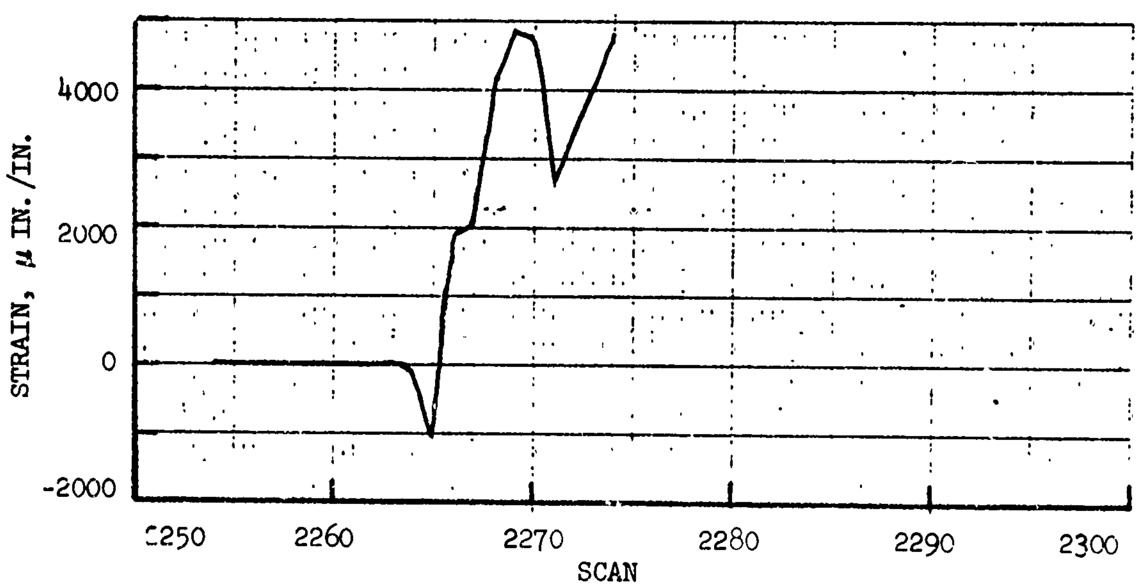


Figure 64. Strain Gage 1A Versus Scan, Test Specimen 8.

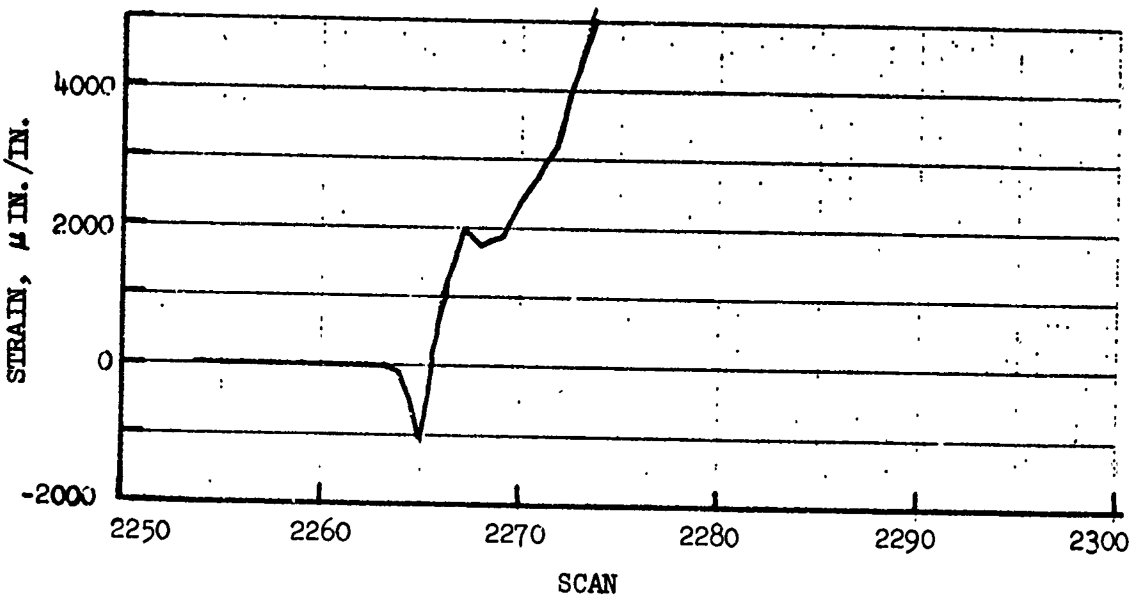


Figure 65. Strain Gage 1B Versus Scan, Test Specimen 8.

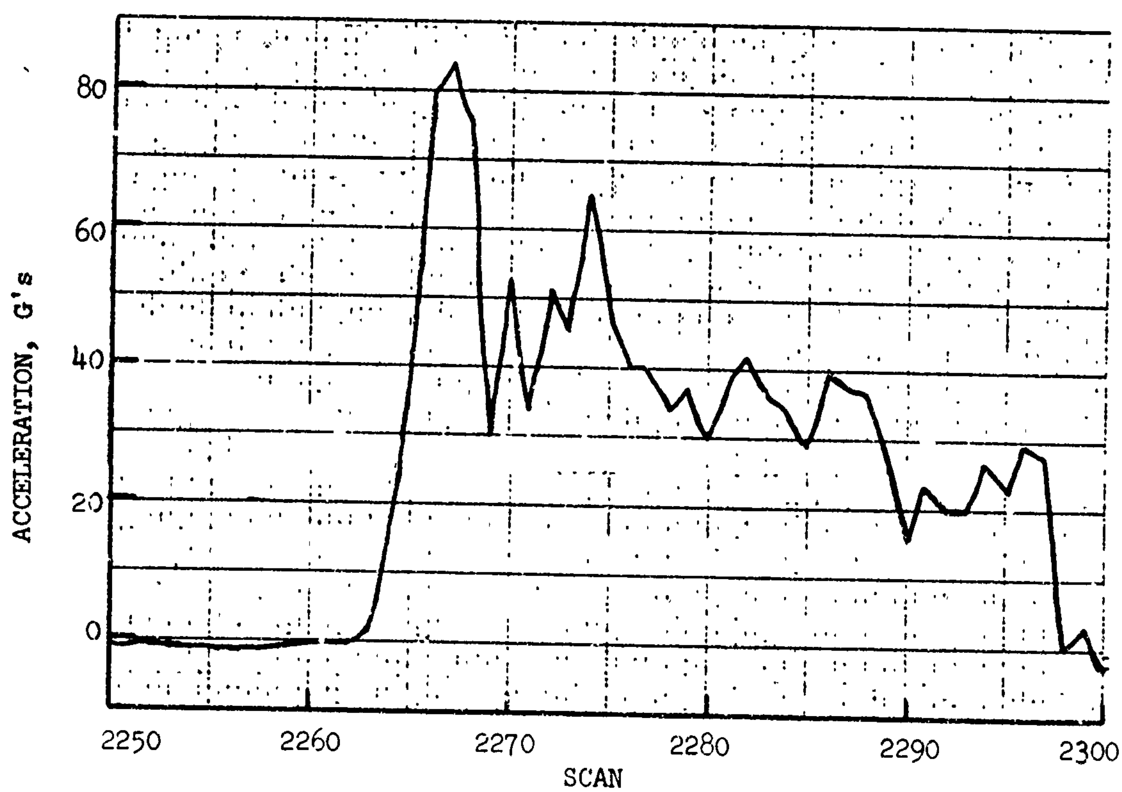


Figure 66. Acceleration (East) Versus Scan, Test Specimen 8.

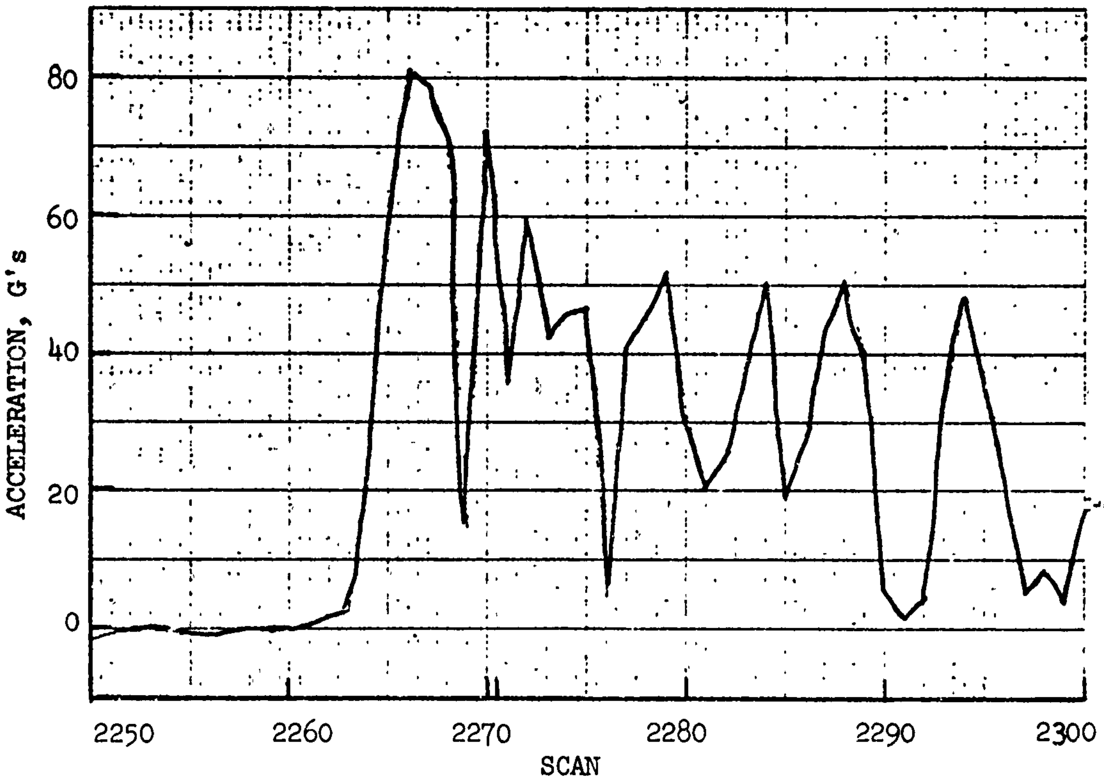


Figure 67. Acceleration (Center) Versus Scan, Test Specimen 8.

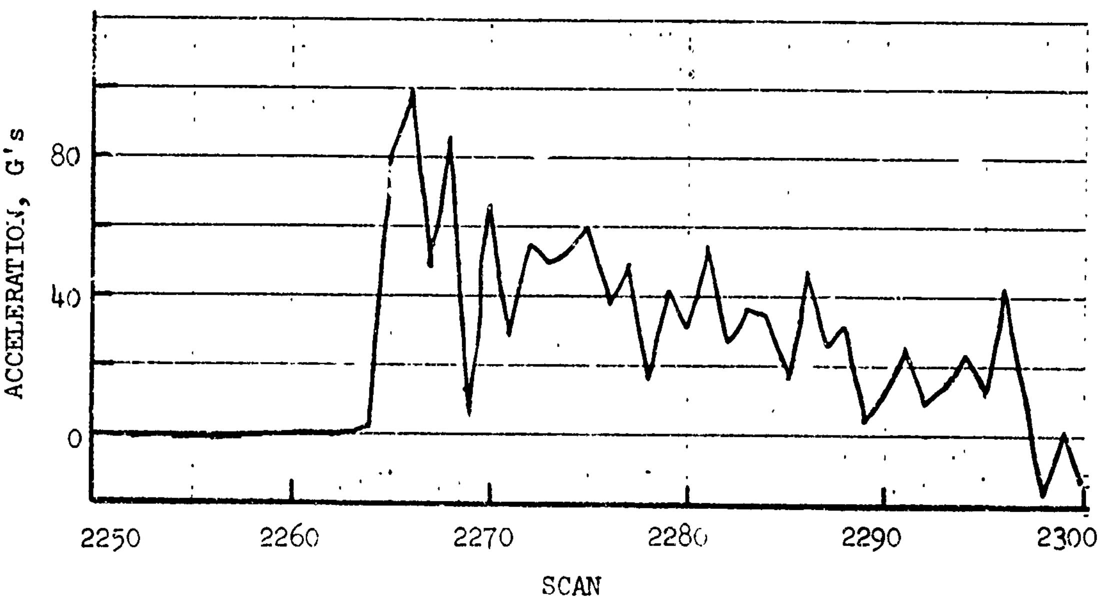


Figure 68. Acceleration (West) Versus Scan, Test Specimen 8.

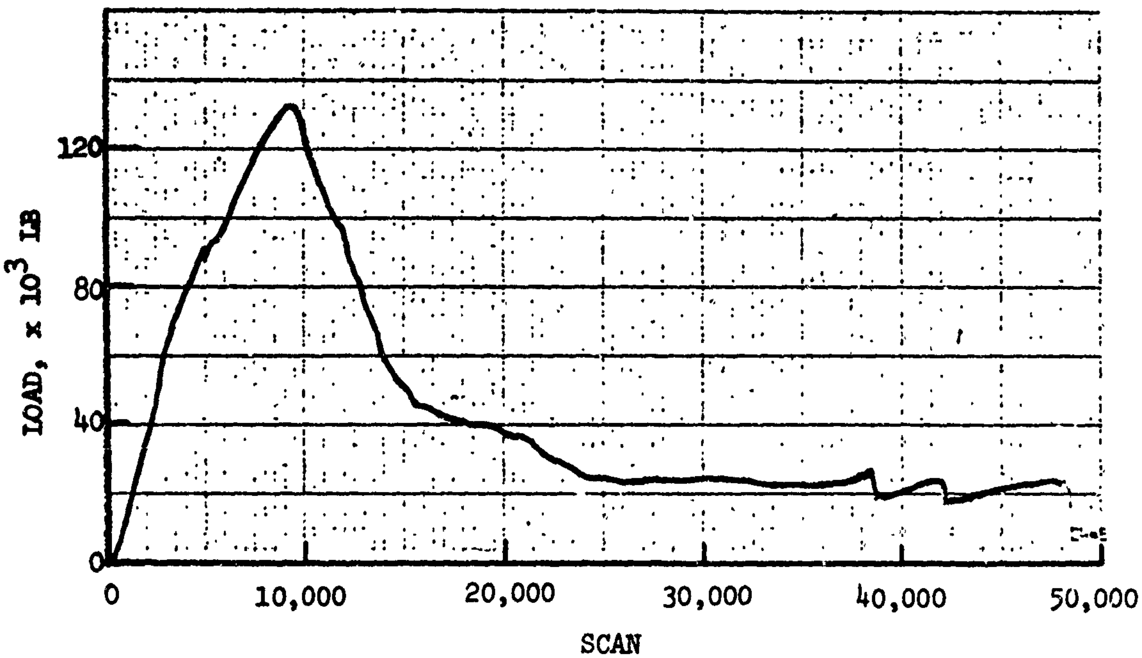


Figure 69. Load Versus Scan, Test Specimen 9.

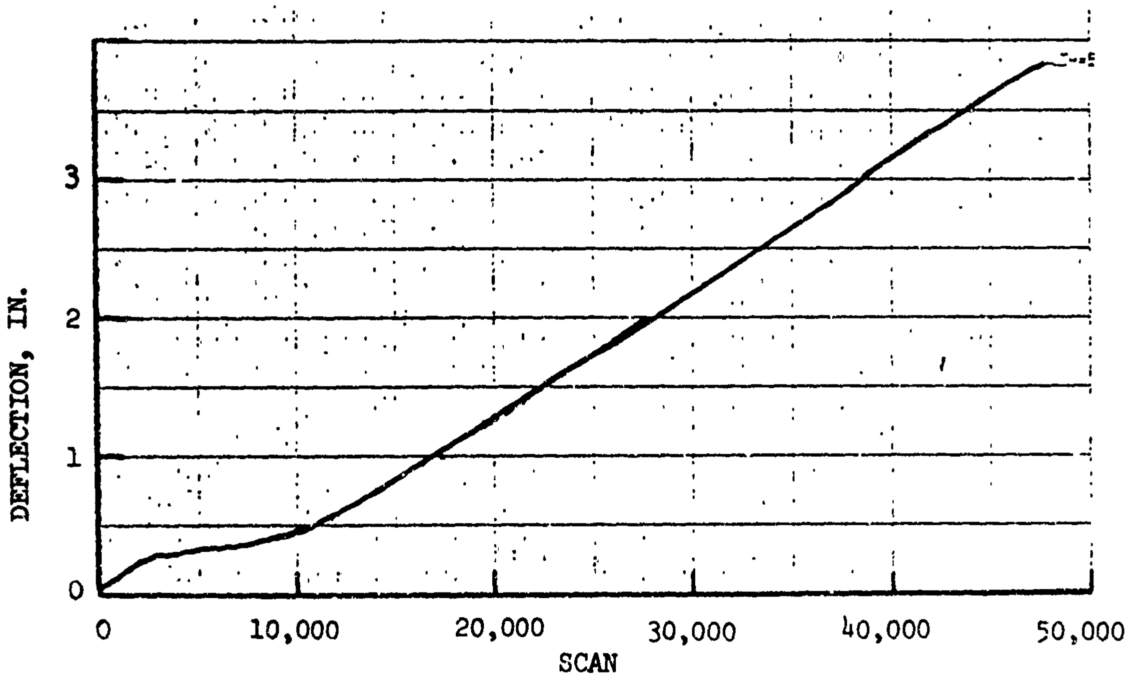


Figure 70. Deflection Versus Scan, Test Specimen 9.

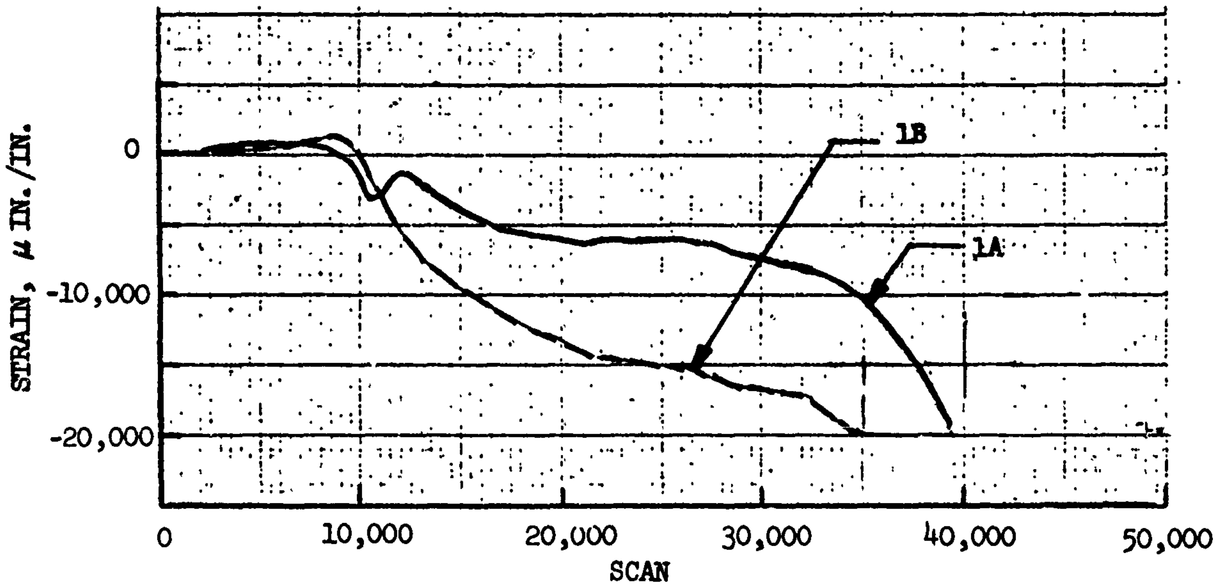


Figure 71. Strain Gages 1A and 1B Versus Scan, Test Specimen 9.

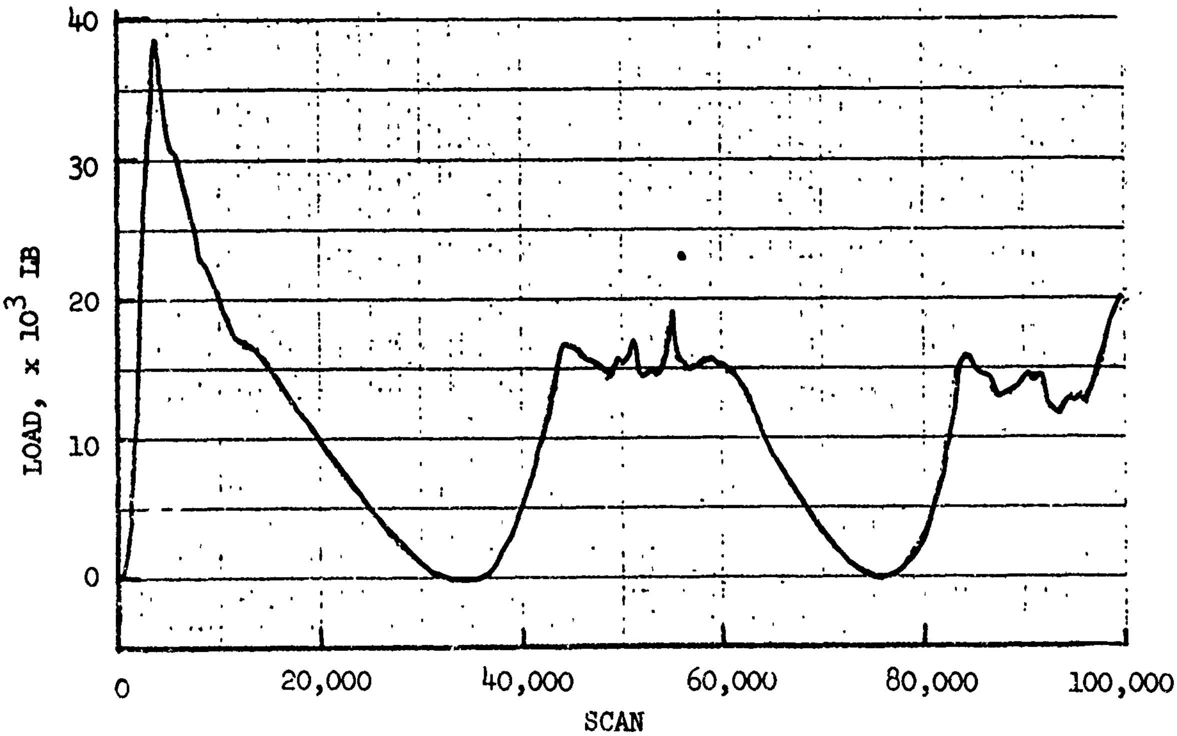


Figure 72. Load Versus Scan, Test Specimen 10.

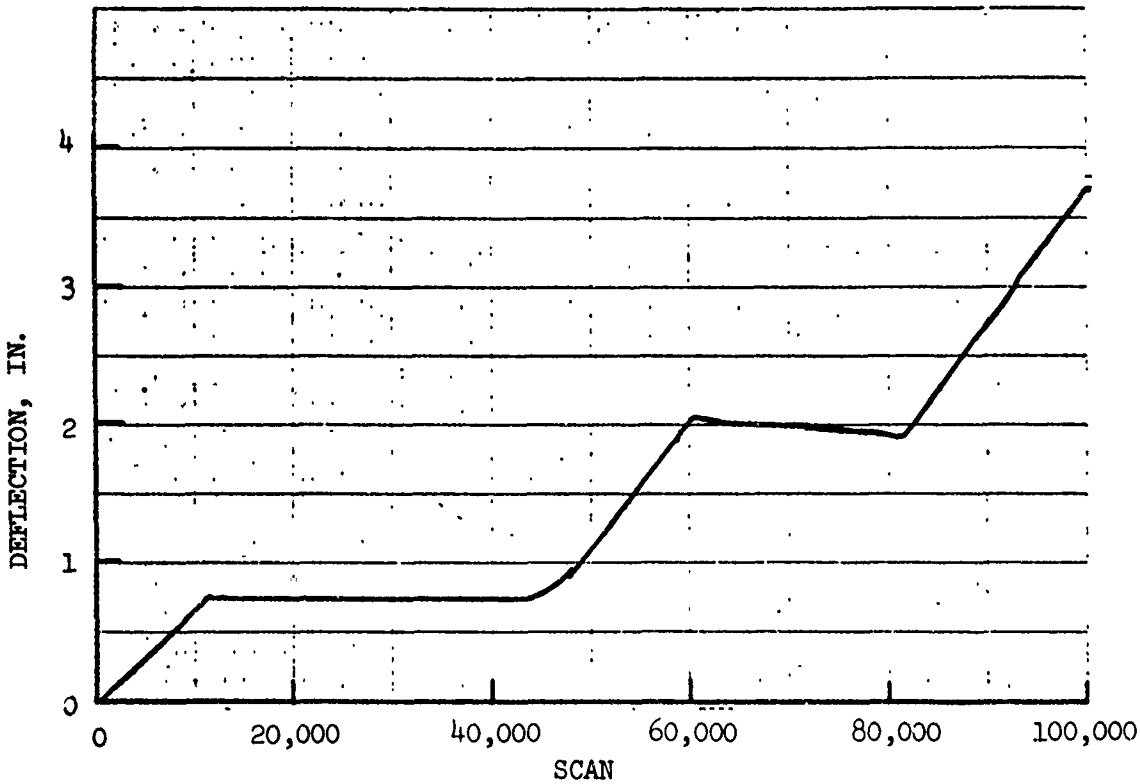


Figure 73. Deflection Versus Scan, Test Specimen 10.

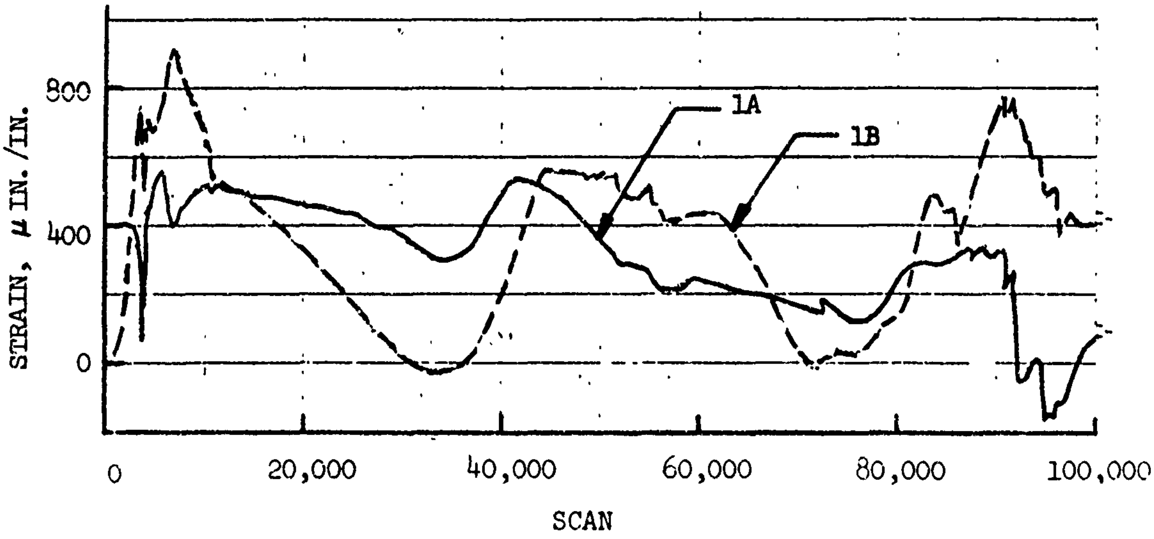


Figure 74. Strain Gages 1A and 1B Versus Scan, Test Specimen 10.

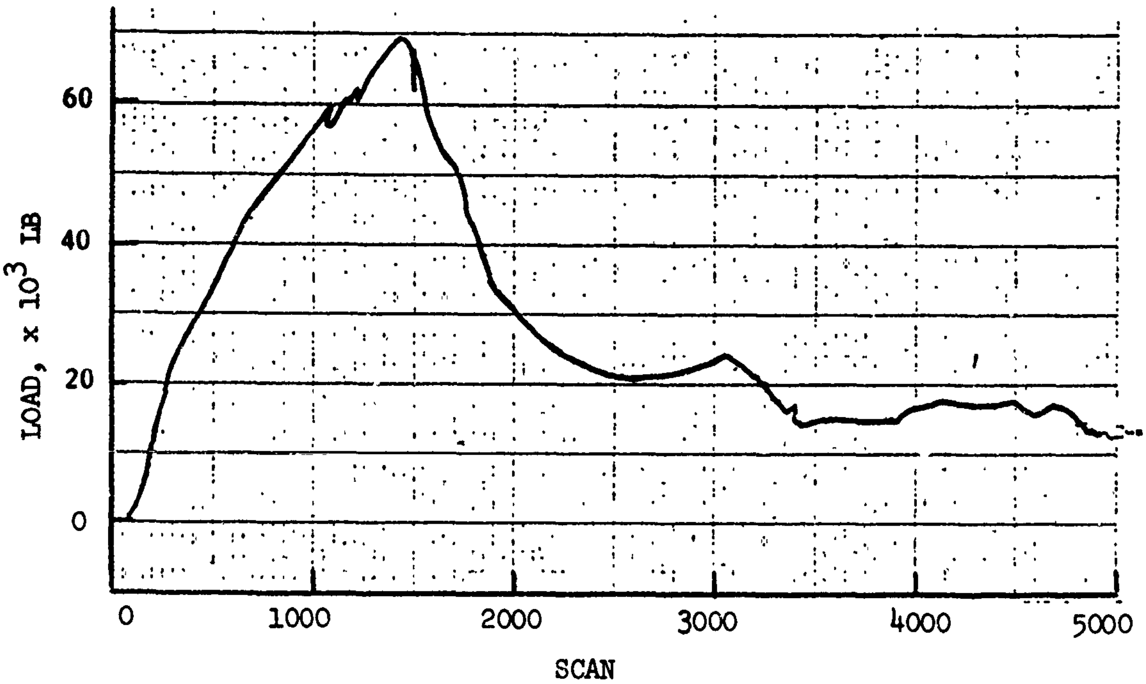


Figure 75. Load Versus Scan, Test Specimen 11.

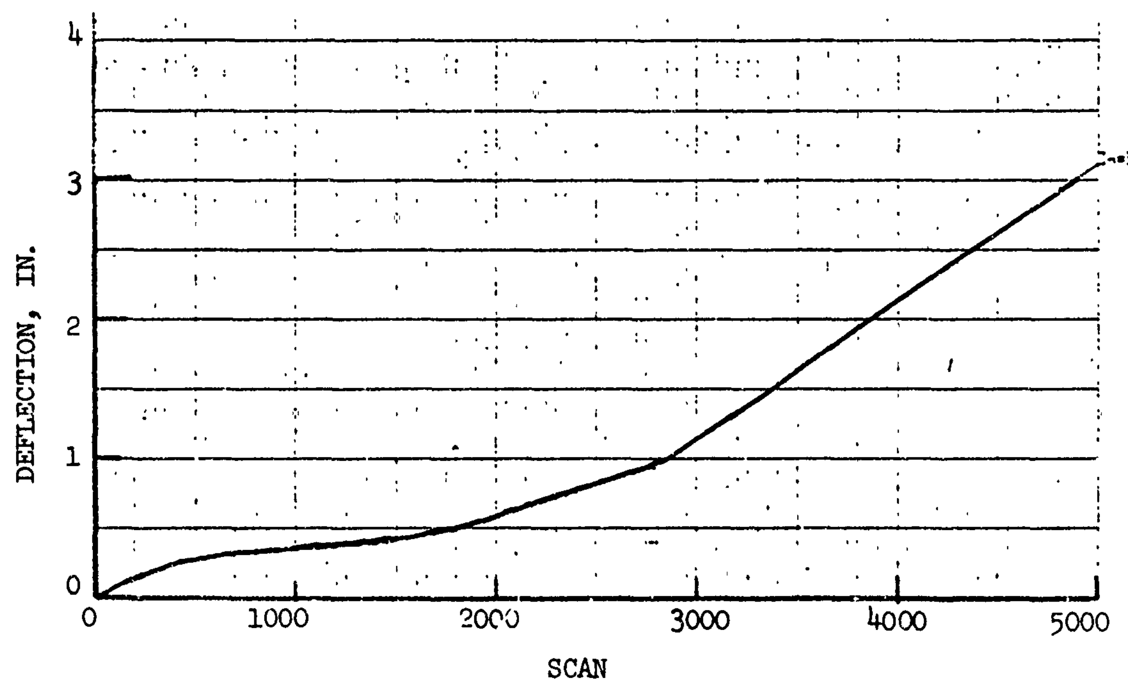


Figure 76. Deflection Versus Scan, Test Specimen 11.

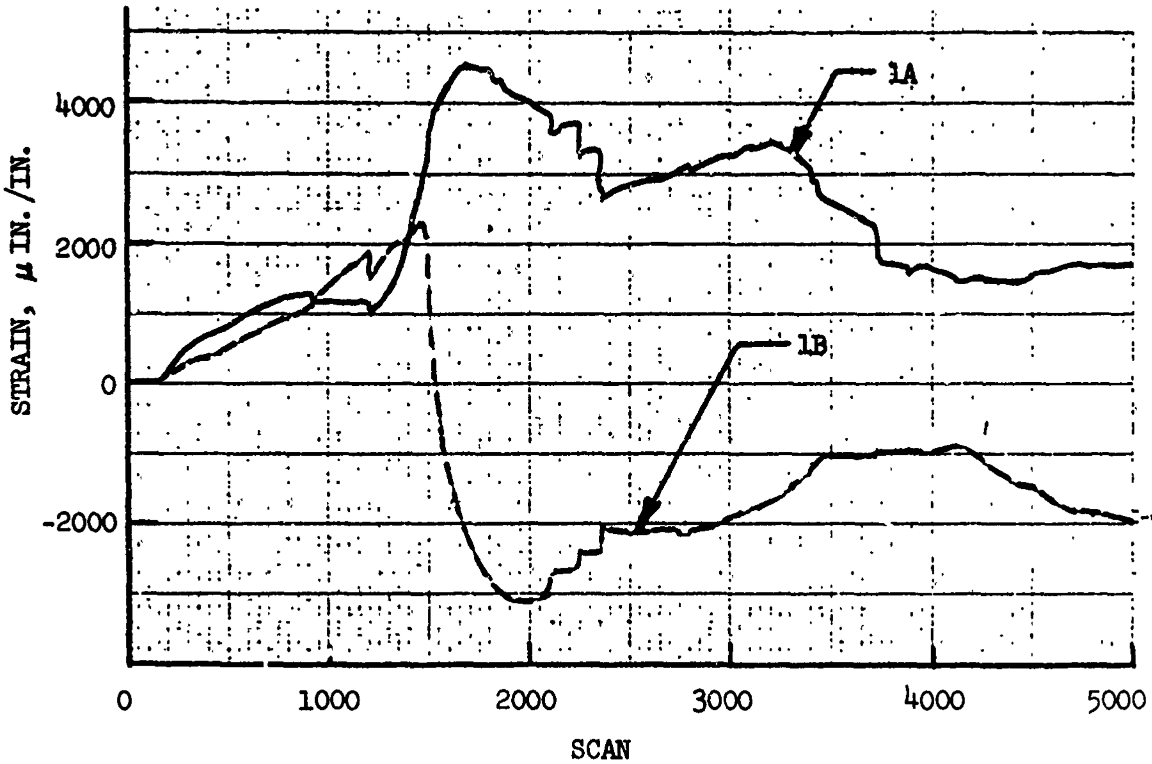


Figure 77. Strain Gages 1A and 1B Versus Scan, Test Specimen 11.

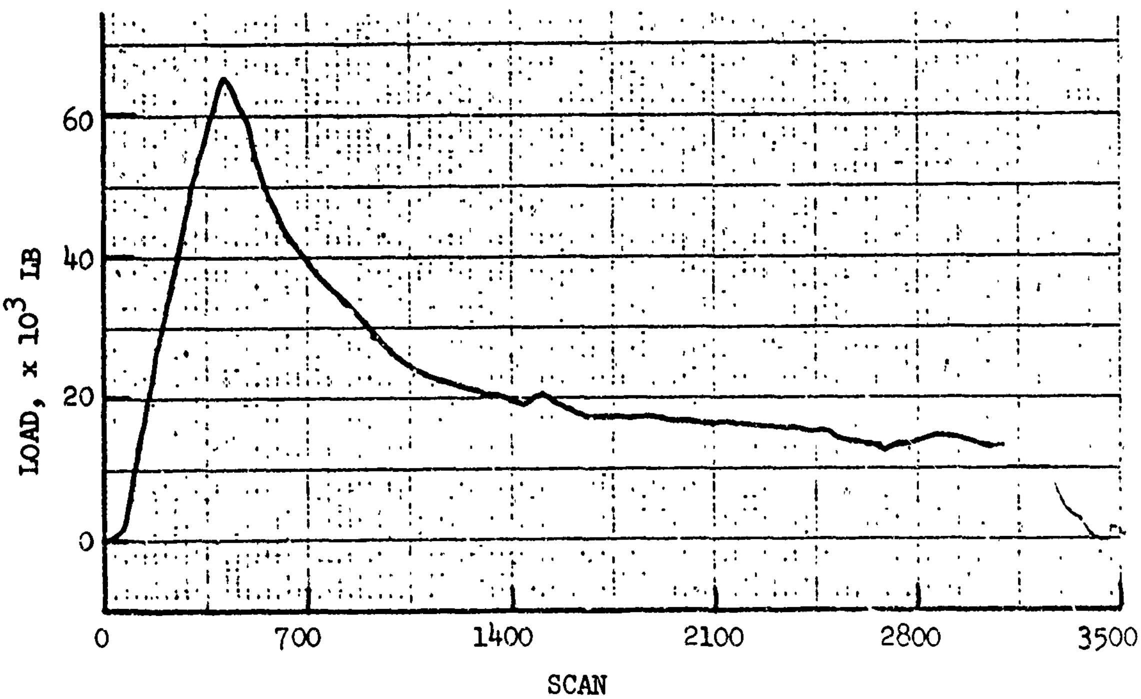


Figure 78. Load Versus Scan, Test Specimen 12.

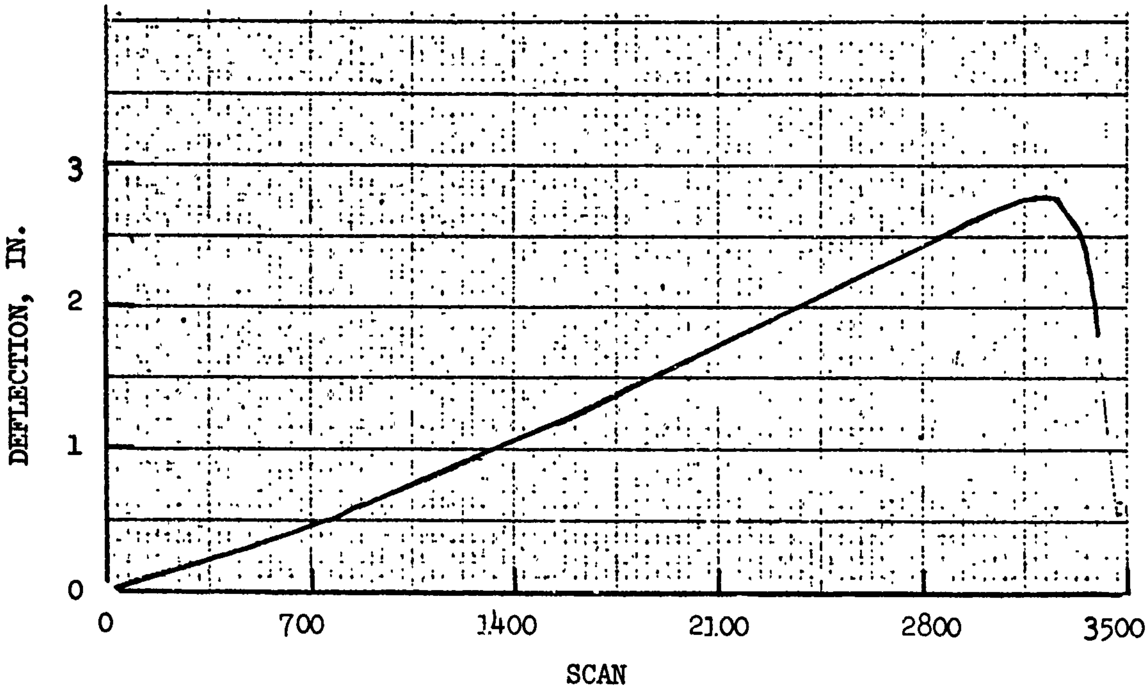


Figure 79. Deflection Versus Scan, Test Specimen 12.

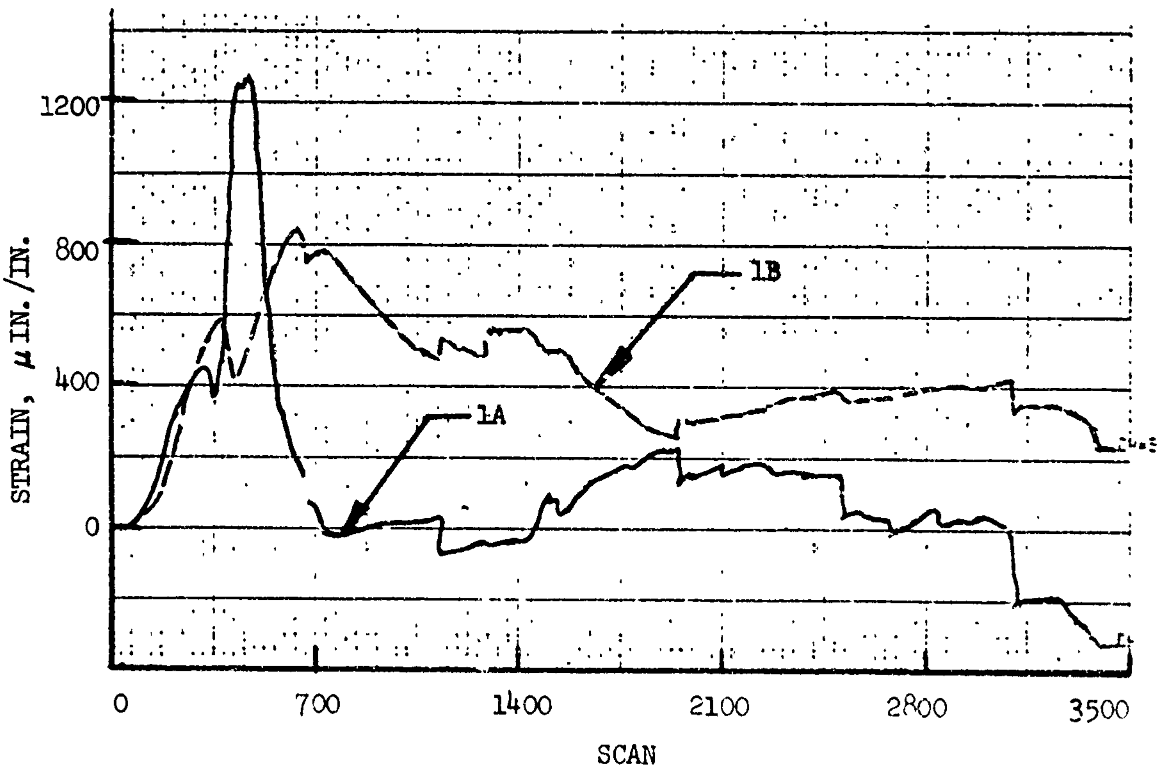


Figure 80. Strain Gages 1A and 1B Versus Scan, Test Specimen 12.

PROGRAM "KRASH" REFINEMENT

GENERAL

Program KRASH was developed as an analytical tool to be used during preliminary phases of design. In Reference 1 the results of a parametric study were integrated into an iterative design procedure by which a tradeoff between potential incremental cost and/or weight versus incremental improvements in crashworthiness capability could be accomplished. The results of that study and a subsequent study for the U.S. Army (Reference 106) showed the potential benefits that could be achieved for designers using a comprehensive but unsophisticated analytical approach. However, as is the situation with rapidly developed advances in the state-of-the-art analytical techniques, there are generally areas which can be simplified for users not thoroughly familiar with the approach.

In an effort to facilitate a designer's usage of program KRASH and to incorporate the results of the literature survey, load sensitivity study, substructure analysis, and tests, the program was revised. In particular, the input data format was changed for ease of data input and subsequent data changes, as would be required during parameter tradeoff studies. In addition, flexibility was added by the manner in which the Stiffness Reduction factors (KR's) are input. The revised program was run for the following conditions:

- Correlation case 31-52 from Reference 1 (to demonstrate that the revised program format was compatible with previous results: 23-ft/sec vertical velocity combined with 18.5-ft/sec lateral velocity impact).
- Three-dimensional velocity (~ 40 ft/sec combined velocity impact - 27.5 ft/sec longitudinal, 23 ft/sec vertical, 18.5 ft/sec lateral).
- Upper mass penetration into a specified occupiable volume.
- Simplified blade contact.
- Utilization of load-deflection data obtained from the 12 substructure tests, performed during the study, and related to actual fuselage structure size.

PROGRAM "KRASH" INPUT FORMAT REVISIONS

The input format changes are divided into three categories:

- Reordered data.
- Standardization of certain inputs.
- Allowance for more general KR curves.

First, the input data is rearranged so that all mass associated data (subscript i) is in one block, followed by all external spring data (subscript ik) and then all internal beam data (subscript ij). Next, standard values are assigned to certain input data items unless otherwise specified. Thus, much repetitive data input is eliminated. The following quantities are given standard values unless otherwise specified:

Quantity	Symbol	Standard Value
Angular Momenta	He_i	0
Euler Angles	$\phi''_i, \theta''_i, \psi''_i$	0
Aerodynamic Lift	lc_i	0
Stiffness Reduction Factors	KR_{ij}	1
Failure Deflection	$\upsilon_{max_{ijl}}$	100

Thus, the angular momenta of the masses (He_i) and the aerodynamic lift (lc_i) are normally zero, as are the Euler angles ϕ'', θ'', ψ''_i, relating mass body-fixed axes to airplane c.g. axes. For linear internal beam elements, KR = 1 for the entire run, so only nonlinear KR data need be input. Similarly, υ_{max}'s need only be input for those elements where rupture is expected to occur; for elements not specified, a failure deflection of 100 inches and rotation of 100 radians are assumed. Thus, the nonspecified beams will not rupture during the run.

The input has also been revised to allow more general KR (stiffness reduction factor) curves. Previously, each KR curve could have only six data points, equally spaced. Now each curve can have up to 15 data points, with any desired spacing. This greatly facilitates modeling more complex load-deflection relationships. However, the load-sensitivity study results indicate that for many structural elements a very simple KR representation is adequate. The KR representation for the various load-deflection categories is discussed in Volume I (Design Procedures).

The relationship between the number of masses, internal beam elements and KR tables is governed by the following expression:

Total number of bytes = 235,136 + 1244 x number of lumped masses (n) + 1372 x Internal Beam Elements (IBE) + 198 x number of KR tables

e.g. N = 80
IBE = 100
KR = 120

bytes = 235136 + 260,480 = 495616 = 484K

where 1K = 1024 bytes.

Thus, program KRASH has some flexibility with regard to the size of problems to which it can be applied. Depending on the type of vehicle that is being analyzed the program can be redimensionalized to provide the most practical and economical solution.

The three-dimensional impact mass penetration, simplified rotor blade contact and updated load-deflection data cases are described in Volume I under the section entitled Program KRASH Refinement.

ENERGY BALANCE EQUATIONS

The primary objective of a crash analysis in the preliminary design phase is to determine how to absorb the initial vehicle kinetic energy while maintaining a livable environment for the occupants. This task is greatly facilitated if information regarding the spatial distribution of the energy flow through the vehicle is available. With the objective in mind, energy balance equations are developed. These equations do not alter the existing computational procedures or results; they merely provide additional information to assist in understanding how the initial kinetic energy is absorbed.

The total system energy at any time is given by the following expression:

$$E_{TOT} = KE + PE + SE + DE + CE \tag{1}$$

where E_{TOT} = Total system energy

KE = Total kinetic energy

PE = Total potential energy

SE = Total strain energy absorbed

DE = Total damping energy dissipated

CE = Total crash spring (external spring) energy absorbed.

The total system energy E_{TOT} remains constant during the analysis. The total kinetic and potential energies for each mass over the number of masses (N) are shown in Equation (2).

$$KE = \sum_{i=1}^{N} KE_i \qquad PE = \sum_{i=1}^{N} PE_i \tag{2}$$

The total strain and damping energies are obtained by summing the strain and damping energy for each interval beam element (ij pair) over the M ij pairs.

$$SE = \sum_{ij=1}^{M} SE_{ij} \qquad DE = \sum_{ij=1}^{M} DE_{ij} \tag{3}$$

SE_{ij} results from the elastic-plastic behavior of the beam, and DE_{ij} results from its damping properties. The total crash spring energy results from summing the energies for all the individual crash springs (ik pairs) over all the P ik pairs.

$$CE = \sum_{ik=1}^{P} CE_{ik} \tag{4}$$

Referring to Equation (1), at time zero all energies are zero except KE, PE and E_{TOT}. The potential energy is referenced to the ground plane.

After impact with the ground, the kinetic and potential energies decrease; damping, strain and crash spring energies all increase to keep E_{TOT} constant.

In Equation (3), the summations over the ij pairs exclude those ij pairs that are identified in the input as DRI elements, which are described in Reference 1, page 73. This is done because these ij beams and their masses are isolated from the rest of the system; the forces in DRI beam ij drive mass j but not mass i. Also, the summations in Equation (2) for the kinetic and potential energies exclude mass j in a DRI ij pair, since this mass is isolated from the system. Thus, if ij pairs 6-9 and 11-15 are defined as DRI elements, the summations for SE and DE will exclude these ij pairs and the summations for KE and PE will exclude masses 9 and 15.

The kinetic energy for each mass, including translational and rotational components, is simply

$$KE_i = \frac{1}{2} \left|vel_i\right|^T \left|M_i\right| \left\{vel_i\right\} \tag{5}$$

where

$$\left|M_i\right| = \begin{bmatrix} M_i & & & & & \\ & M_i & & & & \\ & & M_i & & & \\ & & & I_{xi} & I_{xyi} & I_{xzi} \\ & & & I_{xyi} & I_{yi} & I_{yzi} \\ & & & I_{xzi} & I_{yzi} & I_{zi} \end{bmatrix}$$

and

$$\left\{vel_i\right\} = \begin{Bmatrix} u_i \\ v_i \\ w_i \\ p_i \\ q_i \\ r_i \end{Bmatrix}$$

$\left|M_i\right|$ is the 6 x 6 inertia matrix for mass i, and $\left\{vel_i\right\}$ is a six-element vector of the linear and angular velocity components of mass i in body-fixed axes.

The i^{th} mass potential energy, referenced to the ground plane, is given by

$$PE_i = w_i \ z_i \tag{6}$$

Note that z_i is positive downward, measured from the ground plane.

The strain energy in internal beam ij is computed as a continuous summation of the incremental energy contributions from each integration interval.

$$\left(SE_{ij}\right)_{current} = \left(SE_{ij}\right)_{previous} + \sum_{\ell=1}^{6} F_{ij\ell} \, \Delta vb_{ij\ell} \tag{7}$$

$F_{ij\ell} \, \Delta vb_{ij\ell}$ is the internal beam force (or moment) in the ℓ^{th} direction, multiplied by the incremental beam deflection (or rotation) in the ℓ^{th} direction; this is the incremental strain energy for the integration interval being considered. This straightforward formulation automatically accounts for the complexities of nonlinear, coupled deflections and unloading-reloading behavior, since these are considered in the calculation of F_{ij}.

The damping energy dissipated in internal beam ij is computed in a similar manner:

$$\left(DE_{ij}\right)_{current} = \left(DE_{ij}\right)_{previous} + \sum_{\ell=1}^{6} FD_{ij\ell} \, \Delta vb_{ij\ell} \tag{8}$$

$FD_{ij\ell}$ is the internal beam damping force (or moment) in the ℓ^{th} direction.

The crash spring energy is also computed as a summation of incremental energy changes. The crash spring energy resulting from all the ik springs attached to mass i is

$$\left(CE_i\right)_{current} = \left(CE_i\right)_{previous} - \left\lfloor X_{Ci}\ Y_{Ci} \cdots,\ N_{Ci} \right\rfloor \begin{Bmatrix} \Delta x'_i \\ \Delta y'_i \\ \Delta z'_i \\ \Delta inp_i \\ \Delta inq_i \\ \Delta inr_i \end{Bmatrix} \qquad (9)$$

X_{Ci}, Y_{Ci}, ..., N_{Ci} are the six forces and moments acting on mass i in body-fixed axes, resulting from all ik external springs attached to mass i. These are given by Equations (66) in Reference 1, page 61. The vector $\left\{\Delta x'_i, \Delta y'_i, \Delta z'_i, \Delta inp_i, \Delta inr_i\right\}$ is made up of the six incremental deflections and rotations of mass m_i, in the same body-fixed axes. The first three terms of this vector are given by a simple rotation transformation of the incremental deflections in ground axes, which are obtained directly from numerical integration of the equations of motion.

$$\begin{Bmatrix} \Delta x'_i \\ \Delta y'_i \\ \Delta z'_i \end{Bmatrix} = \left|A_i\right|^T \begin{Bmatrix} \Delta x_i \\ \Delta y_i \\ \Delta z_i \end{Bmatrix} \qquad (10)$$

The last three terms of the incremental displacement vector in Equation (9) are the incremental changes in the integrals of the angular velocities of mass m_i, p_i, q_i, r_i. These are the incremental rotations of mass m_i in body-fixed axes for the integration interval being considered.

The negative sign in Equation (9) results from the fact that the forces acting on mass m_i rather than the forces within the ik springs are being considered. A positive deflection of spring ik results in a negative force on mass m_i. The energy calculated in Equation (9) includes the energy dissipated by the sliding of spring ik on the ground with a friction coefficient; hence the forces in that equation include the ground drag loads due to friction.

The crash spring energies in Equation (9) are not yet in the form desired; the crash spring energy due to each spring ik must be separated out of the total crash spring energy associated with mass m_i, CE_i. This is done

simply by substituting Equations (66) of Reference 1 for the $\left\{X_{Ci}, Y_{Ci}, \ldots, N_{Ci}\right\}$ terms in Equation (9). This reformulates Equation (9) into a function of the individual crash spring forces FSP_{ijk}, where i and k refer to the ik spring and j refers to the direction of the forces on the ik spring. These forces are shown in Figure 10 on page 62 of Reference 1. The final equation for the crash spring energy associated with each spring ik is the following:

$$\left(CE_{ik}\right)_{current} = \left(CE_{ik}\right)_{previous} - \sum_{j=1}^{3} FSP_{ijk}\, \Delta vc_{ij} + TERM_{ik} \qquad (11)$$

where

$$\left\{\Delta vc_i\right\} = \begin{Bmatrix} \Delta x_i \\ \Delta y_i \\ \Delta z_i \end{Bmatrix}$$

and

$$TERM_{ik} = FSP_{i31}\, \ell_{i1}\, \Delta inq_i - FSP_{i2i}\, \ell_{i1}\, \Delta inr_i \qquad (k = 1)$$

$$TERM_{ik} = -FSP_{i32}\, \ell_{i2}\, \Delta inp_i + FSP_{i12}\, \ell_{i2}\, \Delta inr_i \qquad (k = 2)$$

$$TERM_{ik} = FSP_{i23}\, \ell_{i3}\, \Delta inp_i - FSP_{i13}\, \ell_{i3}\, \Delta inq_i \qquad (k = 3)$$

This is the crash spring energy to be used in Equation (4) to obtain the total crash spring energy, CE, for the entire vehicle. Note that CE could have been determined more directly by summing the CE_i from Equation (9) over all the masses m_i. However, the CE_{ik} associated with each spring ik is calculated so that it can be determined how much each external spring is contributing to CE.

<u>ENERGY BALANCE DATA</u>

The energy balance technique described in the preceding section and the information presented in the following paragraphs describe a type of format which can be of benefit to a designer during the preliminary stage of design.

The output format for the energy balance data is shown in Figures 81, 82 and 83. For a condition of 42-ft/sec vertical velocity impact and using program KRASH with the existing UH-1H helicopter math model consisting of 31 masses and 38 internal beam elements, Figure 81 shows that at time = 0.0 second only contributions to the energy term are kinetic and potential energies. The kinetic energy represents the 1/2 MV^2 terms while the potential energy is a function of the height the respective masses are above the ground at the initiation of impact. The internal beam energy contributions due to strain and damping are zero at this time, as is the external spring crushing energy. Figure 82 shows the energy data output during the run at time = .042 second after impact. At this time kinetic energy has decreased from 85.85% of the total energy to 58.6% of the total energy. Similarly, the potential energy has decreased from 14.15% to 8.96% of the total energy. At this time crushing energy, strain energy and damping energy as a percent of the total energy have increased to 9.8%, 7.5% and 15.2%, respectively. Furthermore, Figure 82 shows the following:

- distribution of kinetic energy and potential energy by mass item
- distribution of strain energy and damping energy by beam element
- distribution of crushing energy by external spring element

The negative terms in the damping energy output for beam elements 2 and 4 are of the order of less than .0003 percent of the total energy. The values are obviously insignificant and are considered to reflect damping inherent in the integration routine.

Figure 83 shows a summary of the energy data which is presented at the end of the computer run. The summary shows for each time increment the total energy and the amount and percentage contribution from kinetic, potential, strain damping and crushing. The data in the summary shown in Figure 83 indicates that for the illustrated case the vehicle rebounds at approximately .064 second after impact. The kinetic energy reduces from impact until .064 second after impact,then starts to increase again. The summary data presented in Figure 83 also shows that crushing energy reaches a maximum of 51.73% of the total energy at .062 second after impact and that strain energy reaches a maximum of 21.93% of the total energy at .076 second after impact.

TOTAL ENERGY *	KINETIC ENERGY	POTENTIAL ENERGY	STRAIN ENERGY	DAMPING ENERGY	CRUSHING ENERGY
3.2576D 06	2.79681D 06	4.6084D 05	0.0	0.0	0.0
PERCENT OF TOTAL ENERGY	85.853	14.147	0.0	0.0	0.0

MASS	KINETIC ENERGY	PER CENT	POTENTIAL ENERGY	PER CENT	INTERNAL BEAM IJ	I	J	STRAIN ENERGY	PER CENT	DAMPING ENERGY	PER CENT	EXTERNAL SPRING I	K	CRUSHING ENERGY	PER CENT
1	4.5736E 4	1.635	1.9706E 4	4.276											
2	2.7958E 4	1.000	6.9063E 3	1.499											
3	2.0400E 4	0.729	3.5185E 3	0.764											
4	5.[illegible]594E 4	2.024	8.2045E 3	1.780											
5	9.1472E 4	3.271	1.3260E 4	2.878											
	3.[illegible]E 5	10.965	4.4457E 4	9.647											
7	[illegible].4[illegible]52E 5	8.600	6.4365E 4	13.967											
8	4.6459E 5	16.612	1.4014E 5	30.410											
9	2.9613E 4	1.059	6.8679E 3	1.490											
10	8.4562E 4	3.024	8.0315E 3	1.743											
11	5.9963E 5	21.447	5.6970E 4	12.362											
12	5.7581E 4	2.059	5.4689E 3	1.187											
13	5.7[illegible]1E 4	2.059	5.4689E 3	1.187											
14	7.8968E 3	0.282	5.4024E 1	0.012											
15	7.8966E 3	0.282	5.4024E 1	0.012											
16	3.1258E 5	11.176	2.9688E 4	6.442											
17	7.8[illegible]E 3	0.282	5.4024E 1	0.012											
18	7.8[illegible]E 3	0.282	5.4024E 1	0.012											
19	1.0101E 5	3.612	9.5940E 3	2.082											
20	1.0200E 4	0.365	2.6427E 3	0.573											
21	1.0200E 4	0.365	2.6427E 3	0.573											
22	5.4620E 4	1.953	5.1876E 3	1.126											
23	5.4620E 4	1.953	5.1876E 3	1.126											
24	9.3775E 3	0.335	2.4296E 3	0.527											
25	9.3775E 3	0.335	2.4296E 3	0.527											
26	1.8097E 4	0.647	2.2688E 3	0.492											
27	2.3032E 4	0.824	2.6875E 3	0.627											
28	3.9484E 4	1.412	6.1501E 3	1.335											
29	3.9484E 4	1.412	6.1501E 3	1.335											
30	0.0	0.0	0.0	0.0											
31	0.0	0.0	0.0	0.0											

* D Denote Double Precision

Figure 81. Energy Balance Data Output at t = 0.0 Second

TOTAL ENERGY	KINETIC ENERGY *	POTENTIAL ENERGY	STRAIN ENERGY	DAMPING ENERGY	CRUSHING ENERGY
3.3[illegible] 06	1.9357D 06	[illegible].957[illegible]D 05	[illegible].4685D 05	5.[illegible]54D 05	3.2210D 05
PERCENT OF TOTAL ENERGY	58.665	[illegible]	7.474	15.215	9.752

MASS	KINETIC ENERGY	PER CENT	POTENTIAL ENERGY	PER CENT	INTERNAL BEAM IL	I	J	STRAIN ENERGY	PER CENT	DAMPING ENERGY	PER CENT	EXTERNAL BEAM I	K	CRUSHING ENERGY	PER CENT
1	[illegible]	[illegible]	1.[illegible]747E [illegible]	5.[illegible]	1	1	[illegible]	1.[illegible]65D 1	0.008	1.[illegible]45D 1	0.004	10	3	1.4764D 5	45.[illegible]
[illegible]	2.[illegible]3[illegible]E [illegible]	1.[illegible]	[illegible].11[illegible]E 3	1.[illegible]	[illegible]	[illegible]	[illegible]	[illegible].[illegible]33D 1	0.024	-2.[illegible]7D 1	-0.004	11	3	5.3878D 4	16.[illegible]
[illegible]	1.[illegible]E [illegible]	[illegible]	[illegible]E 3	[illegible].7[illegible]	[illegible]	[illegible]	4	3.[illegible]52D 1	0.013	1.8215D 0	0.000	12	3	4.0787D 3	1.2[illegible]
[illegible]	[illegible]	[illegible]	[illegible].75[illegible]E 3	1.[illegible]	[illegible]	4	5	[illegible].5794D 1	0.010	-[illegible].2497D [illegible]	-0.001	13	3	4.0809D 3	1.257
[illegible]	[illegible]	[illegible]	[illegible].733[illegible] 3	[illegible]	[illegible]	4	[illegible]	[illegible].1901D 1	0.021	1.7038D 1	0.003	14	3	5.2955D 3	1.544
[illegible]	[illegible]	[illegible]	[illegible].[illegible]935 [illegible]	[illegible]	[illegible]	5	[illegible]	[illegible].7513D 1	0.019	2.9828D 1	0.006	15	3	5.2958D 3	1.544
7	1.[illegible]	1[illegible]	[illegible].[illegible]75F 4	1[illegible].6[illegible]	7	5	7	5.17[illegible]D 1	0.021	2.4847D 1	0.005	16	3	6.4115D 4	19.906
[illegible]	3.2[illegible]E [illegible]	1[illegible]	1.1094E 5	37.50[illegible]	8	5	20	1.0090D [illegible]	0.041	1.7220D 1	0.003	17	3	5.1023D 3	1.584
[illegible]	2.1220E [illegible]	1.[illegible]	[illegible].[illegible]41E 3	1.719	9	5	21	1.0058D 2	0.041	1.7223D 1	0.003	18	3	5.1023D 3	1.584
[illegible]	[illegible].[illegible]3E [illegible]	2.493	2.985[illegible]E 3	1.009	10	5	2[illegible]	7.0115D 2	0.284	1.2278D 2	0.024	22	3	1.3751D 4	4.269
11	4.3014E [illegible]	22.2[illegible]	2.[illegible]6E 4	7.054	11	5	23	7.0116D 2	0.284	1.2278D 2	0.024	23	3	1.3751D 3	4.269

* D Denote Double Precision

For Illustrative Purpose Only the Energy Associated with Masses and Structural Members 1 through 11 is shown

Figure 82. Energy Balance Data Output at t = 0.042 Second.

TIME	TOTAL ENERGY*	PERCENT	KINETIC ENERGY	PERCENT	POTENTIAL ENERGY	PERCENT	STRAIN ENERGY	PERCENT	DAMPING ENERGY	PERCENT	CRUSHING ENERGY	PERCENT
0	3.256D6	100.	2.796E6	85.85	4.608E5	14.15	0.0	0.0	0.0	0.0	0.0	0.0
.01	3.259D6	100.04	2.662E6	81.71	4.186E5	12.85	4.883E4	1.5	1.030E5	3.16	2.563E4	0.79
.02	3.269D6	100.35	2.458E6	75.21	2.781E5	11.57	1.145E5	3.6	2.603E5	8.57	3.741E4	1.14
.03	3.296D6	101.15	2.234E6	67.80	3.395E5	10.30	2.221E5	6.74	4.602E5	13.99	3.919E4	1.19
.04	3.303D6	101.39	2.038E6	61.66	3.028E5	9.17	2.432E5	7.38	5.011E5	15.17	2.189E5	6.63
.05	3.303D6	101.41	1.168E6	35.38	2.708E5	8.2	3.081E5	9.33	5.153E5	15.40	1.041E6	31.5
.06	3.303D6	101.4	2.622E5	7.94	2.533E5	7.67	5.231E5	15.84	5.584E5	16.90	1.706E6	51.65
.062	3.303D6	101.4	2.080E5	6.30	2.522E5	7.64	5.698E5	17.08	5.698E5	17.25	1.708E6	51.73
.064	3.303D6	101.47	2.017E5	6.11	2.520E5	7.63	5.815E5	18.24	5.815E5	17.61	1.665E6	50.42
.070	3.303D6	101.46	1.016E5	12.15	2.560E5	7.75	6.112E5	21.03	6.112E5	18.50	1.340E6	40.57
.076	3.305D6	101.46	8.053E5	24.36	2.659E5	8.04	6.298E5	21.93	6.298E5	19.06	8.795E6	26.61
.080	3.307D6	101.53	1.137E5	34.38	2.748E5	8.31	6.467E5	19.53	6.467E5	19.55	6.028E5	18.23

*) denotes double precision

Computer Printout is Every .002 Second. For Illustrative Purpose an Abbreviated Computer Printout is Shown

Figure 83. Energy Data Output Summary.

REVISED USER'S GUIDE

This section describes all the input necessary to run the program, and the output available from the program.

Input

The input data format is described in detail in this section and is shown in Figure 84. Unless otherwise specified, all quantities are input in inch, pound, second, and radian units. For cards 0102 and following the input format is 6E12.0 unless otherwise noted. Each card has 6 fields; each field is 12 columns wide. As an example of this format, the number 126.08 can be input in the following ways:

			1	2	6	.	0	8			
			1	2	6	.		8			

	1	.	2	6	0	8				E	2
	1	2	6	0	8	.			E	-	2

Blank columns are treated as zeros. When the E format is used, the exponent must be right justified in the field. Integer formats with field widths of 1, 2 or 3 are also used. The numbers in these locations must be right justified integers. Sequence numbers in columns 77 through 80 should be used corresponding to those shown in the input format to facilitate deck assembly and changes. All tabular input is linearly interpolated between input values and extrapolated beyond the two end values, if necessary.

Card 0100 - This card contains the title for the case being analyzed. All text material on card 0100 is reproduced at the top of every page of the output and on every plot.

Card 0101 - N is the total number of lumped masses. The maximum allowable number of masses is 80. ΔPrint/Δt is the integer multiple of Δt at which output is printed. Δt is the numerical integration time interval. t_{max} is the time span being analyzed.

Cards 0102 through 0104 - These cards contain the overall vehicle initial conditions. $\dot{x}_G$, $\dot{y}_G$, and $\dot{z}_G$ are the ground axes components of the initial c.g. velocity. p', q', and r' are the c.g. coordinate system components of the initial angular velocity of the vehicle. p' is the roll velocity, q' the pitch velocity, and r' the yaw velocity. ϕ', θ', and ψ' are the Euler angles relating the initial position of the vehicle to ground coordinates. ϕ' is the roll angle, θ' the pitch angle, and ψ' the yaw angle. z_G is the negative of the initial vehicle c.g. height above ground. If this input is zero (blank), the initial condition subroutine computes a value of z_G so that the lowest extremity of the vehicle is .1 inch above the ground.

Cards 0201 through 02XX - N of these cards are used to input the weights (not masses) of the N lumped masses.

Cards 0301 through 03XX - N of these cards are required. Each card inputs the six moments and products of inertia for the ith maxx, i = 1, 2, ..., N.

Cards 0401 through 04XX - N of these cards are used to input the coordinates of the N lumped masses. x_i'' is the Fuselage Station (increasing aft), y_i'' is the Butt Line (positive left), and z_i'' is the Water Line (increasing upward).

Card 0500 - NI is the number of masses having nonzero He_{xi}, He_{yi}, He_{zi} (angular momenta) or ϕ_i'', θ_i'', ψ_i'', which are the Euler angles relating the c.g. axes to the ith mass body fixed axes. The above quantities are normally zero, so only nonzero values are input on cards 050I through 05NI. i_1, i_2, ..., i_{NI} are the actual i's or mass numbers that have nonzero input data for any of the above quantities. NI and i through i_{NI} are input in integer format I2. If NI equals zero, cards 0501 through 05NI are not input; however, card 0500 is always required. If NI equals zero, a bland card for card 0500 is input.

Cards 0501 through 05NI - As noted above, these cards are used to input any nonzero values of He_{xi}, He_{yi} or ϕ_i'', θ_i'', ψ_i''. One card is used for each mass i having nonzero input. The masses are ordered according to the sequence specified on card 0500. He_{xi}, He_{yi}, and He_{zi} are the body axes components of the angular momenta of masses m_i, due to rotation of internal masses within m_i. These are normally zero. ϕ_i'', θ_i'', ψ_i'' are the Euler angles from the c.g. axes to the ith mass axes. If the ith mass body-fixed axes are parallel to the vehicle c.g. coordinate axes. which is usually the case, these are all zero. Note that if any nonzero values are input, then θ_{ij} and ψ_{ij} on cards 0901 through 090M must be input.

Cards 0600 through 06NI - NI is the number of masses having nonzero l_{c_i}, which are the aerodynamic lift constants used in Equation (5) on page 30 of Reference 1. i_1, i_2, ..., i_{NI} are the actual mass numbers having nonzero l_{c_i}: If all l_{c_i} are zero, card 0600 is input as a blank card and cards 0601 through 06NI are not input. One card is used for each nonzero l_{c_i} input, with the ordering defined on card 0600.

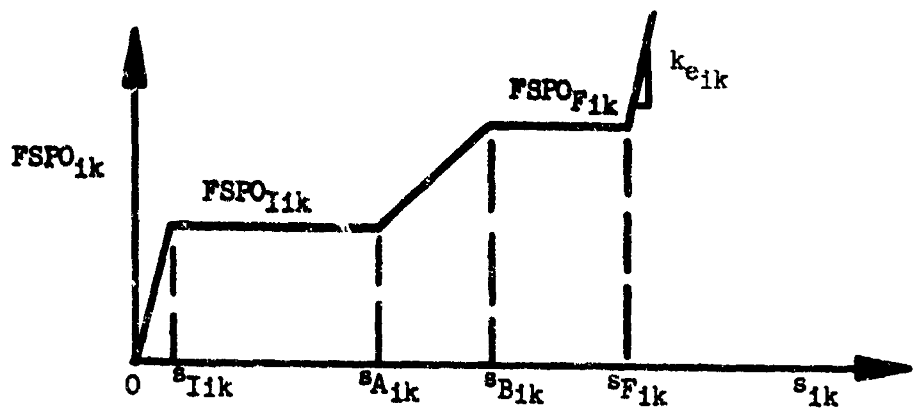
Cards 0701 through 070p - As many cards as necessary are used to input data for the external springs. The maximum allowable number of external springs is 50. Each spring is identified by an ik pair, where i defines the mass to which the spring is attached and k defines the direction of the spring. k = 1, 2 and 3 correspond to springs in the x, y and z directions, in mass i body-fixed axes. l_{ik} is the free length of the external spring ik. l_{ik} is positive if it radiates out from mass m_i in

the positive direction of the ith mass body axes; l_{ik} is negative if it radiates in the opposite direction. Springs in both directions are not allowed. mu_{ik} is the friction coefficient between the ground and the end of the ik spring. ke_{ik} is the linear unloading stiffness and also the bottoming stiffness for the ik spring.

If no external springs are used, card 0701 is input blank and the next card input is 0901.

Card 07XX - A blank card in this location is required to terminate the above ik external spring list.

Cards 0801 through 080p - External spring load-deflection curve parameters are input on these cards, one card per ik spring, ordered as in the ik list on cards 0701 through 070p. The program is written so that a table of the following form is input:



This table is defined by six parameters S_{Iik}, S_{Aik}, S_{Bik}, S_{Fik}, $FSPO_{Iik}$, and $FSPO_{Fik}$, which are input on cards 0801 through 080p.

Cards 0901 through 090M - These cards contain the Euler angles ϕ_{ij}, θ_{ij}, and ψ_{ij} for all internal beams ij. The beam interconnections are defined by the i's and j's input. i must be less than j, but there is no other requirement on the ordering of the ij pairs. ϕ_{ij} is always input; θ_{ij} and ψ_{ij} need not be input if ϕ_i'', θ_i'' and ψ_i'' on cards 0501 through 05NI are all zero. In the latter case, θ_{ij} and ψ_{ij} are computed in initial conditions. ϕ_{ij} will normally be zero. The maximum allowable number of internal beams is 100.

Card 09XX - A blank card is required here to terminate the ij pair internal beam list.

Cards 1001 through 1006 - These six cards are used to input the 6 x 6 linear stiffness matrix $|K_{ij}|$ for the first ij beam, listed on card 0901. Each card inputs one row of the matrix.

Cards 1007 through 1XXX - As many cards as necessary are used to input all the remaining 6 x 6 $|K_{ij}|$ matrices. These matrices must be ordered the same as the ij pairs are ordered on cards 0901 through 090M.

Cards 2001 through 200M - These cards are used to input the $\bar{C}_{ij}$ for all the ij pairs defined on cards 0901 through 090M. $\bar{C}_{ij}$ is the damping ratio (damping/critical damping) for the isolated system consisting of masses m_i and m_j connected by beam ij. Values of $\bar{C}_{ij}$ between .01 and .05 are generally representative of the structural damping.

Cards 2101 through 210q - These cards are used to specify which beam elements (ij pairs) and directions (l) have nonlinear stiffness properties. l varies from 1 to 6 corresponding to the x, y, z, ϕ, θ, ψ, directions in beam axes. Only beam elements and directions having nonlinear properties (KR $\neq$ 1) are input. For each ijl combination listed, a table of KR (stiffness reduction factor) versus deflection is input on the following cards. The NP's are the number of points in the following tables. For all itjl combinations not listed, KR = 1 for the entire run. The maximum allowable number of ijl combinations (nonlinear KR tables) is 80. The maximum allowable number of points per table is 15. For a completely linear analysis, card 2101 is blank and the next card input is 3001.

Card 21XX - A blank card is required here to terminate the ijl list of nonlinear beam/direction combinations.

Cards 2201 through $22NP_1$ - These NP_1 cards are used to input the deflection (vb_{ijl}) versus KR_{ijl} table for the ijl combination listed on card 2101. KR_{ijl} normally starts at 1.0 zero deflection (or rotation), corresponding to linear behavior, and varies in any desired manner thereafter to define a general load-deflection curve. Note that KR is not the actual load, but rather the derivative of load with respect to deflection, i.e., the slope of the load-deflection curve.

Cards 22X1 through 2XXX - As many cards as necessary are used to input the KR_{ijl} vs. vb_{ijl} tables for the remaining ijl combinations listed on cards 2102 through 210q above. Note that each table can have a different number of data points NP_i.

Cards 3001 through 300r - These cards are used to identify which internal beam elements ij have nonstandard maximum deflections for rupture (v_{maxijl}). The standard deflections built into the program are 100 inches for deflections and 100 radians for rotations. These numbers were deliberately chosen to be very high so that rupture would not occur unless reasonable $v_{max's}$ were specified. If no nonstandard $v_{max's}$ are to be input, card 3001 is input blank, and the next card input is 5001.

Card 30XX - This blank card is required to terminate the preceding ij list for nonstandard v_{maxijl}.

Cards 3101 through 310r - These cards are used to input the nonstandard $v_{maxijl's}$, one card for each ij beam specified on cards 3001 through 300r. Each card inputs the six $v_{max's}$ for one ij beam, ordered x, y, z, ϕ, θ, ψ in beam axes. v_{maxijl} defines the maximum allowable deflection before rupture occurs. After rupture, all forces in beam ij go to zero, regardless of the direction in which the rupture occurred.

Cards 5001 through 5025 - These cards are used to specify the time history output plots desired. The only input for these cards is either a 1 or a blank. A 1 results in the output of a time history plot for the response quantity indicated; a blank results in no plot for that item. For example, a 1 in the 13th column of card 5003 specifies that a time history plot of z_{13} is to be generated. For cards 5001 through 5012, the column number in which the 1 is input indicates which mass i is desired. For cards 5013 through 5024, the column number in which the 1 is input indicates which ij pair is desired, where the ij pairs are ordered as on cards 0200 through 02XX.

Plots are available for the displacements, velocities and accelerations of all the lumped masses, all the external spring compressions S_{ik}, and all the beam ij total deflections/rotations (vb_{ij}) and forces/moments (F_{ij}). The latter two items are in beam ij axes. Also available are plots of the DRI (Dynamic Response Index). These are identified by the DRI ij element, as described on card 7000 below. The plot variables are labelled automatically, and the plot scales are chosen automatically. The user merely has to specify which plots are desired. Up to 150 plots can be requested per run. Thirty thousand data points are stored for plotting, with the plot time interval depending on run time and number of plots requested. Thus, if the maximum of 150 plots are requested, 200 points will be saved to generate each plot. If the maximum run time is .2 second, this will give one data point every .001 second. For the types of problems analyzed, this appears to be a marginally acceptable resolution. Requesting fewer plots automatically increases the number of points per plot and, hence, the resolution.

Card 6000 - P is the mass to be used to locate the mass penetration control volume. The format is I2. If no mass penetration calculations are required, this card is input blank and card 6001 is not required.

Card 6001 - xn, xp, yn, yp, zn, and zp are the six distances (all positive), measured from the control mass P to the six sides of the control volume. These are measured along the positive (p) and negative (n) body-fixed axes for mass mp.

Card 7000 - This card is used to specify which internal beam ij elements, if any, are to be treated as DRI (Dynamic Response Index) elements. For example, if the 15th ij pair listed on cards 0901 through 090M is to be a DRI element, then a 1 is input in column 15 of card 7000. For DRI beam elements, the forces in beam ij drive mass j but not mass i. To understand the physical significance of this, refer to Reference 1, page 73, which explains the concept of a DRI.

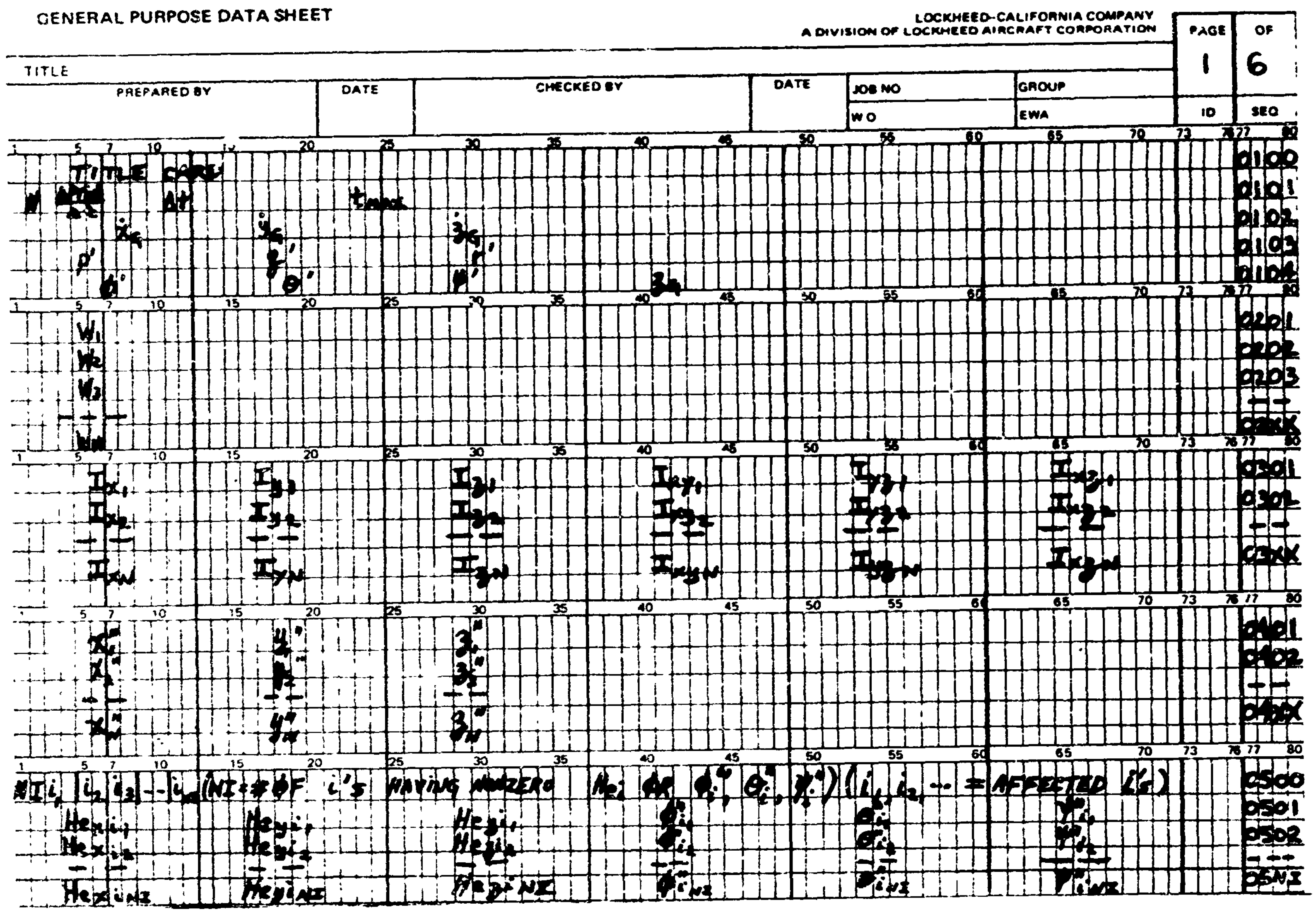
Cards 8000 and 8001 - Cards 8000 and 8001 are used to specify il (mass-direction) pairs for which it is desired to input a time history table of acceleration. Thus, any mass can be driven by a specified acceleration in any direction. The 6 directions are ordered x, y, z, ϕ, θ, ψ in mass i body-fixed axes. The format is 24 (I2I1), where the l is right justified in the field of 3 and the i is right justified in the left two columns of the field of 3. A maximum of 48 input tables are allowed. For example, driving mass 3 in the y direction would be specified as |032|.

When any acceleration table is input, that acceleration replaces the normally computed acceleration, so it becomes a driving force to the system. If less than 24 il pairs are specified, only card 8000 is required (omit 8001). If 24 or more il pairs are input, cards 8000 and 8001 are both required (if exactly 24 il pairs are input, card 8001 will be blank, but must be input).

Card 8010 - N_1 is the number of data points in the following acceleration time history table, applicable to the first il pair on card 8000. The maximum allowable value of N_1 is 50.

Cards 8011 through 801N_1 - N_1 cards are used to input the time history table of acceleration for the first il pair. Each card inputs one time and the corresponding acceleration.

Cards 8XX0 through 8XXN_q - The remaining acceleration time history tables are input on these cards, in the format described above. The tables are ordered according to the sequence of il pairs defined on cards 8000 and 8001.



GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

PAGE 1 OF 6

TITLE | PREPARED BY | DATE | CHECKED BY | DATE | JOB NO | W O | GROUP | EWA | ID | SEQ

TITLE CARD — 0100

N NMB Δt t_{max} — 0101

x_c y_c z_c — 0102

p' q' r' — 0103

ϕ' θ' ψ' z_A — 0104

W_1 — 0201

W_2 — 0202

W_3 — 0203

— — 02XX

W_N

I_{x_1} I_{y_1} I_{z_1} I_{xy_1} I_{yz_1} I_{xz_1} — 0301

I_{x_2} I_{y_2} I_{z_2} I_{xy_2} I_{yz_2} I_{xz_2} — 0302

— — 03XX

I_{x_N} I_{y_N} I_{z_N} I_{xy_N} I_{yz_N} I_{xz_N}

X_1'' y_1'' z_1'' — 0401

X_2'' y_2'' z_2'' — 0402

— — 04XX

X_N'' y_N'' z_N''

NI i_1 i_2 i_3 -- i_{NI} (NI = # OF i's HAVING NONZERO He_i OR ϕ_i'', θ_i'', ψ_i'') (i_1, i_2, -- = AFFECTED i's) — 0500

$He_{x_{i_1}}$ $He_{y_{i_1}}$ $He_{z_{i_1}}$ ϕ_{i_1}'' θ_{i_1}'' ψ_{i_1}'' — 0501

$He_{x_{i_2}}$ $He_{y_{i_2}}$ $He_{z_{i_2}}$ ϕ_{i_2}'' θ_{i_2}'' ψ_{i_2}'' — 0502

— — — —

$He_{x_{i_{NI}}}$ $He_{y_{i_{NI}}}$ $He_{z_{i_{NI}}}$ $\phi_{i_{NI}}''$ $\theta_{i_{NI}}''$ $\psi_{i_{NI}}''$ — 05NI

Figure [illegible]. Input Data Format.

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

TITLE:							PAGE	OF
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO.	GROUP		2	6
				W O	EWA		ID	SEQ

Col 1–10	Col 15–25	Col 30–35	Col 40–45	Col 50–60	Col 65–70	SEQ (77–80)
NI i_1 i_2 i_3 — i_N (NO. OF i's HAVING NONZERO R_{ij})(i_1, i_2 — = AFFECTED i's)						0600
$R_{i i_1}$						0601
$R_{i i_2}$						0602
— —						— —
$R_{i i_{NI}}$						06NI
i_1 K_1	l_{ik_1}	Mu_{ik_1}	Ke_{ik_1}	(INPUT iK PAIRS DEFINING		0701
i_2 K_2	l_{ik_2}	Mu_{ik_2}	Ke_{ik_2}	EXTERNAL SPRINGS)		0702
— — — —	— —	— —	— —			— —
i_p K_p	l_{ik_p}	Mu_{ik_p}	Ke_{ik_p}			070P
(BLANK CARD REQUIRED TO TERMINATE iK LIST)						07XX
SI_{ik_1}	SA_{ik_1}	SB_{ik_1}	SF_{ik_1}	$FSPO_{Iik_1}$	$FSPO_{Jik_1}$	0801
SI_{ik_2}	SA_{ik_2}	SB_{ik_2}	SF_{ik_2}	$FSPO_{Iik_2}$	$FSPO_{Jik_2}$	0802
— —	— —	— —	— —	— —	— —	— —
SI_{ik_p}	SA_{ik_p}	SB_{ik_p}	SF_{ik_p}	$FSPO_{Iik_p}$	$FSPO_{Jik_p}$	080P
i_1 j_1	ϕ_{ij_1}	θ_{ij_1}	ψ_{ij_1}			0901
i_2 j_2	ϕ_{ij_2}	θ_{ij_2}	ψ_{ij_2}	(INPUT ij PAIRS DEFINING		0902
— —	— —	— —	— —	INTERNAL BEAMS)		— —
i_N j_N	ϕ_{ij_N}	θ_{ij_N}	ψ_{ij_N}			090N
(BLANK CARD REQUIRED TO TERMINATE ij LIST)						09XX
$K(ij)_{11}$	$K(ij)_{12}$	$K(ij)_{13}$	$K(ij)_{14}$	$K(ij)_{15}$	$K(ij)_{16}$	1001
$K(ij)_{21}$					$K(ij)_{26}$	1002
$K(ij)_{31}$	(INPUT 6x6 K MATRIX FOR 1ST ij INTERNAL BEAM)				$K(ij)_{36}$	1003
$K(ij)_{41}$					$K(ij)_{46}$	1004
$K(ij)_{51}$					$K(ij)_{56}$	1005
$K(ij)_{61}$	$K(ij)_{62}$	$K(ij)_{63}$	$K(ij)_{64}$	$K(ij)_{65}$	$K(ij)_{66}$	1006

Figure 84. (Continued)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

TITLE	PREPARED BY	DATE	CHECKED BY	DATE	JOB NO / WO	GROUP / EWA	PAGE 3 / ID	OF 6 / SEQ

Cols 1–10	Cols 11–72	SEQ
	(INPUT REMAINING 6x6 K MATRICES FOR EACH (ij) BEAM,	1001
	6 CARDS PER MATRIX. ORDER MATRICES SAME AS (ij) ELEMENTS	—
	ARE ORDERED ON CARDS 0901–090M.)	—
		1XXX
C_{ij1}		2001
C_{ij2}		2002
—		—
C_{ijM}		200M
i_1 j_1 ℓ_1 NR_1	(THESE CARDS ARE USED TO SPECIFY WHICH BEAM ELEMENTS (ij) AND	2101
i_2 j_2 ℓ_2 NR_2	DIRECTIONS (ℓ) (x, y, z, φ, θ, or ψ) HAVE NONLINEAR STIFFNESS	2102
— — — —	PROPERTIES (KR ≠ 1). ALL ijℓ COMBINATIONS NOT LISTED ARE LINEAR (KR=1)	—
i_g j_g ℓ_g NR_g	FOR ALL DEFLECTIONS. NR IS # OF POINTS IN FOLLOWING KR TABLE.)	210g
	(BLANK) CARD REQUIRED TO TERMINATE ijℓ LIST)	21XX
$vb(ij\ell_1)_1$	$KR(ij\ell_1)_1$ (DEFLECTION (vb) VERSUS STIFFNESS REDUCTION FACTOR (KR)	2201
$vb(ij\ell_1)_2$	$KR(ij\ell_1)_2$ TABLE INPUT FOR 1ST NONLINEAR ijℓ COMBINATION,	2202
—	— USING NP CARDS	—
$vb(ij\ell_1)_{NP}$	$KR(ij\ell_1)_{NP}$	22NP
$vb(ij\ell_g)_1$	$KR(ij\ell_g)_1$	22X1
$vb(ij\ell_g)_2$	$KR(ij\ell_g)_2$ (vb VERSUS KR TABLES INPUT FOR REMAINING	22X2
—	— ijℓ COMBINATIONS.)	—
$vb(ij\ell_g)_{NP_g}$	$KR(ij\ell_g)_{NP_g}$	22XX

Figure . . (Continued)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

TITLE						PAGE 4	OF 6
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO / WO	GROUP / EWA	ID	SEQ

Cols 1–10	Cols 15–72	SEQ
i_1 j_1	(THESE CARDS ARE USED TO SPECIFY WHICH BEAM ELEMENTS (i_j)	3001
i_2 j_2	HAVE NON-STANDARD MAXIMUM DEFLECTIONS, INPUT ON FOLLOWING	3002
— —	CARD SET. STANDARD MAXIMUM DEFLECTION = 100 INCHES OR RADIANS.)	— —
i_r j_r		300r
		30XX

Cols 1–12	Cols 13–24	Cols 25–36	Cols 37–48	Cols 49–60	Cols 61–72	SEQ
$v_{max}(ij1)_1$	$v_{max}(ij1)_2$	$v_{max}(ij1)_3$	$v_{max}(ij1)_4$	$v_{max}(ij1)_5$	$v_{max}(ij1)_6$	3101
$v_{max}(ij2)_1$	$v_{max}(ij2)_2$	$v_{max}(ij2)_3$	$v_{max}(ij2)_4$	$v_{max}(ij2)_5$	$v_{max}(ij2)_6$	3102
— —	—	— —	— —	— —	— —	— —
$v_{max}(ijr)_1$	$v_{max}(ijr)_2$	$v_{max}(ijr)_3$	$v_{max}(ijr)_4$	$v_{max}(ijr)_5$	$v_{max}(ijr)_6$	310r

Figure . (Continued)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

TITLE:							PAGE	OF
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO	GROUP		5	6
				WO	WA		ID	SEQ

PLOT OUTPUT CARDS

1 in m^{th} column means plot that item for mass $i = m$

1 in n^{th} column means plot that item for n^{th} ij pair

Item (col. 65)	SEQ (cols. 77–80)
x_i	5001
y_i	5002
z_i	5003
$\dot{x}_i$	5004
$\dot{y}_i$	5005
$\dot{z}_i$	5006
[illegible]	5007
q_i	5008
[illegible]	5009
S_{i1}	5010
S_{i2}	5011
S_{i3}	5012
V_{ij1}	5013
V_{ij2}	5014
V_{ij3}	5015
V_{ij4}	5016
V_{ij5}	5017
V_{ij6}	5018
F_{ij1}	5019
F_{ij2}	5020
F_{ij3}	5021
F_{ij4}	5022
F_{ij5}	5023
F_{ij6}	5024
DR_{ij}	5025

Figure 8.. (Continued)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

TITLE:						PAGE	OF
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO.	GROUP	6	6
				W.O.	EWA	ID	SEQ

P $\bar{x}_n$ $\bar{x}_p$ $\bar{y}_n$ $\bar{y}_p$ $\bar{z}_n$ $\bar{z}_p$ 8000 8001

DRI ELEMENT SPECIFICATION 7000

il_1 il_2 il_3 — — — — — — — — — il_g 8000 8001

N_1 8010

t_1 ACC_{11} 8011

t_{12} ACC_{12} 8012

t_{1N_1} ACC_{1N_1} 801N_1

N_g 8XX0

t_1 ACC_{g1} 8XX1

t_2 ACC_{g2} 8XX2

t_{N_g} ACC_{gN_g} 8XXN_g

F . . . (Continued)

Print Output

First, all the input data is printed out, with self-explanatory identifying titles. Next, at each print time ($= \Delta\text{Print}/\Delta t \times \Delta t$), the data shown in Figure 85 is printed out. At the top of each page, the case identification data is printed out (from input card 0100). Then the current value of time t is printed.

Next, for each of the N masses, five lines of data are output. x_i, y_i, and z_i are the ground coordinates of m_i. $\dot{x}_i$, $\dot{y}_i$, and $\dot{z}_i$ are the ground axes components of the velocity of m_i. $\dot{u}_i$, $\dot{v}_i$, $\dot{w}_i$ are the time derivatives of u_i, v_i, and w_i. (These are not equal to the acceleration of m_i, as can be seen from Equation (81), Reference 1.) XACCEL, YACCEL, ZACCEL are the body axes components of the acceleration of m_i.

ϕ, θ, and ψ are the Euler angles defining the attitude of body m_i, in roll, pitch and yaw. $\dot{\phi}_i$, $\dot{\theta}_i$, and $\dot{\psi}_i$ are the time derivatives of ϕ_i, θ_i, and ψ_i. $\dot{p}_i$, $\dot{q}_i$, and $\dot{r}_i$ are the body axes components of the angular velocity of m_i; they are the velocities in roll, pitch, and yaw, respectively. p_i, q_i, and r_i are the body axes components of the angular acceleration of m_i.

Following that output, the running time sums of the internal forces $\left\{F_{ij}\right\}$ (Equation (27), Reference 1) are printed out; the six forces and moments for each ij pair are printed on a line preceded by the identifying i and j. Next, the running time sums of the beam deflections $\left\{\nu_{b_{ij}}\right\}$ (Equation (26), Reference 1) are printed out in the same format.

Finally, the external spring compressions s_{ik} (Equation (47), Reference 1) are printed out. Each line starts with the i, followed by the s_{ik} for $k = 1, 2, 3$. Only values of i for which a spring is input are shown.

During the course of the run, if any ruptures or control volume mass penetrations occur, the appropriate information is printed out. When a rupture occurs, the word RUPTURE is printed, followed by four items:

1. The ij pair that ruptured, where the numbering corresponds to the ordering of the ij pairs as input on cards 0200 through 02XX.

2. The l (from 1 to 6) indicating in which direction (in beam axes) the rupture occurred. These are ordered x, y, z, ϕ, θ, and ψ. See Figure 24 (Reference 1) for the directions of the beam axes.

3. The $\nu_{b_{ijl}}$ at the time of rupture. This is the total deflection, in beam axes, in the direction of the rupture.

4. The $\nu_{max_{ijl}}$ which defines the maximum allowable beam deflection in the l^{th} direction. This is an input constant.

If a control volume mass penetration occurs, the mass which penetrates and the time are printed out. At the end of the run, the ruptures and mass penetrations that occurred during the run are summarized in tables for ready reference.

Sample Cases

Two sample cases are presented. The first sample case represents a combined vertical and lateral impact condition. The vertical impact velocity is 23 ft/sec and the lateral impact velocity is 18.6 ft/sec. The mathematical model is the 31 mass representation shown in Volume I, Figure 6 and Table VI. The sample output for one time period is shown in Figure 85. The input data, which follows the User's Guide Input format (Figure 84), is presented in Figure 86.

Sample output plots are provided for the engine mass vertical velocity, engine mass vertical acceleration and engine mount support vertical deflection in Figures 87, 88 and 89, respectively. Figures 90, 91 and 92 provide similar sample plots for the lateral velocity, lateral acceleration and mount lateral displacement, respectively. Figures 93 and 94 show the forward and aft DRI plots, respectively, for the combined vertical and lateral impact velocity case. The engine vertical responses shown in Figures 87 (velocity), 88 (acceleration) and 89 (displacement) can be compared to Figures 17, 18 and 19 in Volume II, Reference 1 to show that the revised program KRASH performs in the same manner as the final submitted program KRASH from the previous study (Reference 1).

The second sample case provided in this section is the three-dimensional velocity impact condition. The initial c.g. velocity for this case is a combined 40 ft/sec velocity in which the velocity vector components are:

$$V_x = 27 \text{ ft/sec} \qquad V_y = 18.6 \text{ ft/sec} \qquad V_z = 23 \text{ ft/sec}$$

The initial vehicle attitude is flat (zero roll, pitch and yaw angles), and the initial angular velocities are zero. Figure 101 (page 140) in Volume I shows the mathematical model representation for this condition The model consists of 32 lumped masses. It is the same model used in the previous sample problem except for the extra mass location which represents the rotor blade during a potential mass penetration (of the upper cabin) condition. The input data for this sample problem is provided in Figure 95. A sample output for one time period is shown in Figure 96. Figures 97 through 99 show the engine mass vertical, lateral and longitudinal velocities, respectively. Figures 100 through 102 present the engine mass vertical, lateral and longitudinal accelerations, respectively. Figures 103 through 105 show the engine support mount vertical, lateral and longitudinal deflections, respectively. The forward and aft DRI's are presented in Figures 106 and 107.

Program Listing

A complete listing of the computer program KRASH, including subroutines, is presented in Figure 108.

RUN 31-52 DROP TEST CORRELATION 206/186 ENGINE 100

TIME = 0.15000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 1	-3.250560 02	-4.317090 01	-1.106250 02	-8.361200-02	9.347450-02	-1.601300-02
	-1.930260 02	-1.715540 02	1.702990 02	-1.276540 00	4.516750 00	1.657800 00
	-2.053190 02	-1.873710 02	1.357490 02	-1.431280 00	4.352960 00	2.043800 00
	-3.506280 02	1.497320 03	-5.605120 03	-5.452120 01	1.41[illegible]60 02	5.834700 01
	1.614580 00	3.295260 00	-1.1[illegible]090 01			
MASS 2	-2.661260 02	-3.917940 01	-5.452410 01	-2.275900-02	5.227000-02	3.797920-02
	-1.446050 01	-7.145320 01	-2.025450 01	-3.938050-01	6.004730-01	-3.878030-[illegible]1
	-1.608150 01	-7.035360 01	-2.273050 01	-3.735440-01	6.091310-01	-3.73508[illegible]
	2.307880 03	3.825090 03	-7.145730 03	-5.934810 01	-3.199530 01	-4.206[illegible] 1
	5.875000 00	9.903130 00	-1.641880 01			
MASS 3	-1.023130 02	-3.267750 01	-3.726080 01	-1.929990-02	3.215990-02	3.293480-02
	-2.123310 00	-1.085660 02	-1.011980 02	6.164260-01	3.824960-01	-1.067390-02
	-2.439980 00	-1.064550 02	-1.034030 02	6.167690-01	3.826310-01	-3.284760-03
	9.054170 02	-6.119310 02	-6.050930 02	-2.245050 01	-3.372250 01	-7.738650 00
	2.242230 00	-1.420070 00	-2.253410 00			
MASS 4	-7.246160 01	-3.155460 01	-2.908360 01	-1.934330-02	2.628370-02	3.047130-02
	1.497750 00	-1.130470 02	-1.120220 02	6.995640-01	3.579740-01	1.058750-01
	9.975790-01	-1.108520 02	-1.142000 02	6.967810-01	3.558600-01	1.127420-01
	5.765360 02	-5.147920 02	-5.828620 00	-1.785700 01	-1.984840 01	2.546640 00
	1.42[illegible]710 00	-1.127220 00	-2.161230-01			
MASS 5	-2.3[illegible]0 01	-3.011490 01	-3.033350 01	-1.938630-02	2.512670-02	2.876610-02
	9.2[illegible]840-01	-1.062580 02	-1.297590 02	7.068600-01	3.765770-01	1.790510-01
	1.132230 00	-1.037050 02	-1.318070 02	6.963610-01	3.730370-01	1.862610-01
	5.397[illegible]30 02	-3.576660 02	8.804820 02	-1.781500 01	-1.638310 01	3.840880 00
	1.320[illegible]0 00	-6.88780[illegible]-01	2.092860 00			
MASS [illegible]	-1[illegible]410 00	-2.452470 01	-3.083570 01	-1.947340-02	2.079660-02	2.537870-02
	[illegible]1910-01	-1.012070 02	-1.353660 02	7.049810-01	4.611280-01	2.365620-[illegible]
	8.[illegible]-01	-9.845330 01	-1.413430 02	7.000620-01	4.564350-01	2.454450-[illegible]
	3.3[illegible]740 [illegible]	-1.315000 02	1.068360 03	-1.806800 01	-4.855560-01	1.672730 01
	7.568[illegible]0 01	-8.379550-02	2.588210 00			
MASS 7	-4.891240 01	-3.181350 01	-7.003260 01	-2.166540-02	2.590640-02	2.931840-02
	-1.326[illegible]70 01	-8.455370 01	-1.226060 02	6.222380-01	3.239300-01	1.580260-01
	-1.24[illegible] 01	-8.135820 01	-1.28[illegible]40 02	6.181440-01	3.204310-01	1.649530-01
	1.722[illegible] 03	1.513070 02	9.466610 02	3.196940 01	-2.349160 01	8.335260 00
	[illegible] 00	5.926710-01	2.332540 00			
MASS 8	2.420[illegible]10 00	3.075200 01	-8.175580 01	[illegible]300-02	1.066320-02	6.315720-02
	-3.882600 01	-3.027150 01	-1.460640 02	5.[illegible]3010-01	6.652860-01	4.513780 00
	-3.909440 01	-2.153480 01	-1.475330 02	5.281700-01	4.736310-01	4.537640 00
	-2.394060 03	-1.079560 02	1.010520 03	5.796460 01	5.832480 00	-1.574990 02
	-6.130110 00	-5.3744[illegible]0-01	2.636430 00			

Figure 85. Output Data Format.

RUN 31-52 DROP TEST CORRELATION 206/186 ENGINE 100

TIME = 0.16000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 9	-2.246780 00	-3.024200 01	-5.943700 01	-2.916510-02	6.843480-03	2.781560-02
	-1.508220 01	-7.036700 01	-1.400950 02	1.375520 00	5.797620-01	6.234240-01
	-1.607430 01	-6.580190 01	-1.421880 02	1.371250 00	5.613360-01	6.400510-01
	-7.337330 02	-4.533550 02	1.203420 03	2.233270 00	5.829820 01	-6.552810-01
	-1.998530 02	-6.960330-01	2.907300 00			
MASS 10	-2.360240 01	-2.971910 01	-1.406110 01	-1.872680-02	1.204580-02	2.430870-02
	7.861460 00	-1.182090 02	-1.068850 02	5.719250-01	2.512350 00	3.508480-01
	6.273040 00	-1.163440 02	-1.090150 02	5.676990-01	2.505340 00	3.978060-01
	4.308890 02	2.924900 02	-1.324950 03	-3.101970 01	-4.414450 00	7.304090 00
	5.786340-01	9.245420-01	-3.644340 00			
MASS 11	-1.608210 00	-2.918580 01	-1.438820 01	-2.069040-02	1.628410-02	2.342370-02
	6.995640 00	-1.126740 02	-1.394260 02	7.104940-01	3.943200-01	9.124290-02
	6.624670 00	-1.099000 02	-1.416400 02	7.090080-01	3.022670-01	9.750740-02
	3.493150 02	-1.223560 02	1.040640 03	1.837500 01	6.261370 00	1.954090 01
	8.217710-01	-5.514580-02	2.488920 00			
MASS 12	6.487680 01	1.739160 01	-1.750720 01	-7.587180-02	5.052170-02	1.602980-02
	-3.061890 00	-1.150860 02	-2.251460 02	-3.959520 00	4.635010-01	1.345040-01
	6.470020 00	-9.762990 01	-2.331790 02	-3.966320 00	4.519850-01	1.690790-01
	-1.971370 03	1.142580 03	4.902580 02	2.466370 02	-3.456910 01	-.599440 01
	-5.337450 00	5.668720-01	2.265710 00			
MASS 13	6.87 040 01	-7.254030 01	-1.368730 01	-6.458330-02	4.210670-02	2.134310-02
	1.0 1970 01	-1.016340 02	4.693570 01	-8.345480-01	4.714490-01	-1.821620-03
	6.305120 00	-1.046720 02	4.057470 01	-8.344710-01	4.705840-01	2.861040-02
	-6.120580 02	1.276240 03	-5.114460 03	-7.663390 01	-5.813970 00	-4.439880 01
	-2.046550 00	3.394520 00	-1.303140 01			
MASS 14	-2.474030 01	3.352010 01	-5.710330 00	-2.394670-02	-2.083170-02	-4.393490-03
	-1.334810 00	-5.924960 01	-9.793830 01	9.730470 00	-3.449400-02	-3.882300-01
	-3.114330 00	-5.689390 01	-9.928550 01	9.722380 00	-2.319020-02	-3.888600-01
	2.766320 01	-9.757430 02	9.390280 02	3.213280-03	1.239040 00	3.700740-17
	2.083020-02	-2.393920-02	9.996960-01			
MASS 15	-2.310070 01	-1.129530 02	-1.527050 01	-3.879390-01	-3.685620-02	-2.027020-02
	1.846400 01	-4.042250 02	-1.378360 02	-7.200280 00	-1.355450-01	-4.214320-02
	2.317670 01	-3.953040 02	-3.114660 02	-7.201830 00	-1.095410-01	-9.025910-02
	1.578470 01	2.099300 03	-2.492380 03	3.240300-03	-2.130350-01	-1.480300-16
	3.684780-02	-3.780250-01	9.250620-01			
MASS 16	6.774830 01	-2.757710 01	-1.551980 01	-3.044230-02	4.960170-02	1.927090-02
	6.841040 00	-1.062290 02	-3.608440 01	-3.083130 00	1.261520-01	-6.180880-02
	6.575970 00	-1.052020 02	-3.902260 01	-3.080070 00	1.279720-01	-5.786450-02
	1.288980 02	1.239540 03	-5.010420 03	6.789490 01	-1.702950 02	1.945110 01
	3.052250-01	2.898880 00	-1.214310 01			

Figure 85. (Continued)

RUN 31-52 DROP TEST CORRELATION 206/186 ENGINE 100

TIME = 0.16000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 17	6.684800 01	3.775960 01	-1.281830 01	-8.290660-01	5.116340-02	1.501400-02
	-4.731800-01	-5.326640 01	-1.484620 02	-6.948340 00	6.704840-01	-1.650590-01
	6.321300 00	7.338950 01	-1.394720 02	-6.939650 00	5.780280-01	3.797480-01
	8.474770 01	6.812590 02	7.733780 02	1.257660-01	1.509920 00	-5.921190-16
	-5.114100-02	-7.363360-01	6.740810-01			
MASS 18	6.871500 01	-8.782210 01	-2.048780 00	3.233970-01	3.869920-02	-7.829380-03
	2.256600 01	-2.034400 02	-4.859340 01	-5.316740 00	9.987470-01	-5.701320-02
	2.602010 01	-2.078540 02	1.943920 01	-5.314540 00	9.288690-01	-3.714090-01
	4.420820 01	2.892850 01	-7.147630 02	-1.976630-01	-1.130930 00	2.368487-15
	-3.868950-02	3.175520-01	9.474510-01			
MASS 19	1.163090 02	-2.663440 01	-1.773340 01	-3.997890-02	4.329920-02	1.961530-02
	5.055820 00	-1.099180 02	-6.906340 01	-6.012650 00	9.696770-01	-6.313840-02
	5.885650 00	-1.071560 02	-7.321460 01	-6.009920 00	9.714240-01	-2.427250-02
	1.255630 02	2.267400 03	7.979270 02	1.805780 02	-1.410960 02	1.397480 01
	1.343000-01	4.733780 00	3.720740 00			
MASS 20	-2.081830 01	1.425480 01	-6.684040 01	-1.643080-02	-7.418530-02	1.436410-02
	2.938720 01	-6.132680 01	-9.920930 01	6.511850-01	-6.393630-01	3.309120-01
	2.078530 01	-7.986470 01	-1.025170 02	6.757110-01	-6.453360-01	3.181620-01
	-5.820890 03	-1.069690 03	7.690350 02	-1.607060 00	1.234950 02	3.750260 01
	-1.484280 01	-2.574640 00	1.887260 00			
MASS 21	-1.953940 01	-7.572410 01	-6.708930 01	-1.888470-02	-6.250030-02	1.668300-02
	6.859500 01	-8.752200 01	-1.469380 02	3.757020-01	-8.467930-01	6.262200-01
	5.781670 01	-8.578980 01	-1.524910 02	4.148150-01	-8.584440-01	6.088950-01
	-3.578300 03	-1.566430 03	2.344530 03	-3.586840 01	1.045040 02	2.822620 01
	-8.795750 00	-3.803030 00	6.110300 00			
MASS 22	-2.465260 01	1.525340 01	-1.495310 01	-2.149180-02	-6.930850-02	2.406060-02
	-1.195140 01	-1.167490 02	-9.399850 01	4.788720-01	-8.454700-01	4.478460-01
	-2.123100 01	-1.144060 02	-9.523150 01	5.098870-01	-8.548760-01	4.284980-01
	-1.239830 02	-2.414130 02	4.408800 02	-1.277250 01	8.357080 01	4.297910 01
	1.671310-02	-5.231960-01	9.440280-01			
MASS 23	-2.273990 01	-7.476860 01	-1.318470 01	-1.774360-02	-5.798190-02	1.809590-02
	1.909670 01	-1.164020 02	-1.390930 02	5.712470-01	-9.246600-01	1.796260-01
	8.898350 00	-1.142290 02	-1.418930 02	5.816570-01	-9.276960-01	1.628900-01
	2.920230 02	-3.246010 02	1.270380 03	-2.208490 01	7.397640 01	-9.801970 00
	1.145760 00	-6.233640-01	3.140380 00			
MASS 24	6.424810 01	1.397830 01	-7.134360 01	-5.191360-02	-.998740-02	2.372530-02
	-2.884590 01	-1.823340 02	-2.214790 02	2.025430 00	5.086360-01	-1.359640-02
	-2.205530 01	-1.697900 02	-2.319820 02	2.026110 00	5.086510-01	1.292190-02
	-4.840530 02	2.904510 03	9.432120 02	-3.031750 02	-2.214770 01	7.504970 00
	-1.554030 00	8.741560 00	1.581400 00			

Figure 85. (Continued)

RUN 31-52 DROP TEST CORRELATION 20G/18G ENGINE 100

TIME = 0.16000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 25	6.660340 01	-7.591430 01	-6.753460 01	-5.895890-02	4.171910-02	2.490420-02
	-1.466410 01	-1.660940 02	5.146460 01	-1.986510 00	5.186540-01	-2.285290-02
	-2.094560 01	-1.683720 02	4.078470 01	-1.985560 00	5.190980-01	7.768230-03
	-7.347380 02	1.592620 03	-5.298070 03	1.579070 02	1.294380 00	-3.559680 00
	-1.845230 00	4.335330 00	-1.283130 01			
MASS 26	-2.370340 01	-2.990670 01	-2.385880 01	-2.139070-02	8.891090-03	2.200410-02
	-1.863460 01	-1.135900 02	-1.250880 02	5.221490-01	3.139160 00	1.042850-01
	-2.001630 01	-1.104470 02	-1.276630 02	5.212220-01	3.136210 00	1.714010-01
	6.087720 02	-6.628750 02	8.266570 02	4.907930 01	6.118920 01	7.141520 00
	5.889270-01	-1.553800 00	2.155090 00			
MASS 27	6.724060 01	-2.788650 01	-2.548030 01	-3.227090-02	5.655880-02	2.072320-02
	2.734080 00	-1.356300 02	-3.524180 01	-2.603510 00	1.208470 00	-1.576990-01
	1.915300 00	-1.344520 02	-3.954850 01	-2.594600 00	1.212930 00	-1.183730-01
	2.109680 03	1.798760 03	-5.253490 03	3.688530 01	-1.917910 02	-1.058730 01
	5.299980 00	4.393580 00	-1.271230 01			
MASS 28	-2.373880 01	-3.007900 01	-3.171600 01	-2.237010-02	6.561220-03	2.190770-02
	-4.413620 01	-1.115760 02	-1.844580 02	3.467860-01	3.344450 00	2.548860-02
	-4.535850 01	-1.064220 02	-1.871870 02	3.466190-01	3.343050 00	1.002910-01
	-1.010980 02	-5.931900 02	-5.922580 03	8.122920 01	7.816030 01	3.572040 00
	-1.855440 00	-1.380460 00	-1.504620 01			
MASS 29	6.671000 01	-2.818710 01	-3.501200 01	-3.293750-02	5.832960-02	2.212800-02
	-1.586140 01	-1.621940 02	-1.094040 02	-2.296150 00	1.689350 00	-6.244020-02
	-1.303530 01	-1.580810 02	-1.156200 02	-2.292510 00	1.690480 00	-6.6 [illegible]7240-03
	3.727900 03	1.969660 03	1.347160 03	4.205270 00	-1.726290 02	-1.732330 01
	9.146690 00	4.416280 00	4.486010 00			
MASS 30	-2.373770 01	-3.004410 01	-3.018080 01	-2.257820-02	6.992260-03	2.159860-02
	-3.951080 01	-1.115250 02	-1.576750 02	3.535020-01	3.378030 00	1.329320-02
	-4.080670 01	-1.070510 02	-1.604220 02	3.534090-01	3.376870 00	8.955300-02
	1.505480 02	-8.018650 02	-8.253480 03	8.524400 01	6.534030 01	4.482140 00
	-9.885700-01	-1.939960 00	-2.112310 01			
MASS 31	6.677720 01	-2.815190 01	-3.370860 01	-3.259630-02	5.872520-02	2.212480-02
	-1.452480 01	-1.590080 02	-1.262080 02	-2.293700 00	1.695710 00	-4.603280-02
	-1.060050 01	-1.544230 02	-1.321530 02	-2.290990 00	1.696300 00	9.338400-03
	3.574080 03	1.761180 03	-2.192790 03	-6.867590 00	-1.721900 02	-1.665390 01
	8.682260 00	3.778030 00	-4.717680 00			

IG(IJ),JG(IJ),SUMDF(1,IJ),SUMDF(2,IJ),SUMDF(3,IJ),'SUMDF(4,IJ),SUMDF(5,IJ),SUMDF(6,IJ)

1	2	-1.356560 03	9.422560 01	-4.297280 02	0.0	-6.998340 04	-1.735290 04
2	3	1.620810 02	1.420760 03	-3.063890 03	6 911040 03	-6.800300 05	-2.262900 05
3	4	-3.205860 02	1.535530 03	-2.662980 03	-2.643780 04	-8.040650 05	-2.634190 05
4	5	2.354140 02	5.672020 01	-6.737560 02	6.353610 04	-1.028930 06	-2.932140 05
4	7	-5.214180 02	-1.305070 03	2.124940 03	0.0	4.264330 04	-2.202220 04
5	6	4.684850 03	-9.189030 03	1.667720 04	-1.281430 05	-7.676130 05	-1.314530 05
5	7	3.529950 03	-1.799270 03	-1.790770 03	0.0	-2.614870 04	-4.482160 03
5	20	-3.248680 03	0.0	1.068330 03	0.0	3.322110 04	0.0
5	21	-7.616340 02	0.0	-7.413280 02	0.0	-3.085030 04	0.0
5	22	-4.725690 02	0.0	-7.830700 03	0.0	-1.770430 05	0.0

Figure 85. (Continued)

5	23	-1.20354D 04	0.0	[illegible]	[illegible]	-2.39273D 05	0.0
6	9	3.06178D 03	-3.96678D 03	9.16165D 03	-5.61331D 04	-1.63525D 05	-2.08246D 05
6	11	1.74979D 04	5.49727D 03	9.32375D 03	-1.66558D 05	-2.68395D 05	6.69139D 04
7	9	0.0	0.0	0.0	-1.71369D 04	0.0	0.0
8	9	3.85139D 03	1.97020D 03	8.62194D 03	-8.41786D 04	1.93635D 05	-1.73460D 05
10	11	1.62915D 03	4.15183D 03	-2.78042D 03	-4.76844D 03	2.95481D 02	-6.13953D 04
10	14	-1.34937D 03	-1.61285D 02	-9.45984D 02	7.00954D 03	1.88089D 05	2.47095D 03
10	15	-2.27221D 03	-5.40466D 02	-1.23499D 03	1.26773D 03	1.78630D 05	1.52115D 03
10	22	-5.72976D 02	-3.49166D 02	2.00029D 03	0.0	1.08264D 05	1.41834D 03
10	23	5.83720D 03	-1.65621D 03	5.61783D 03	0.0	1.39185D 05	8.81597D 03
11	16	7.66696D 02	-3.94270D 03	6.68522D 03	-7.20873D 03	3.09424D 05	-1.05955D 05
12	16	-2.57608D 03	-1.07066D 03	-8.58193D 03	1.03812D 03	-3.07660D 04	7.04336D 04
12	24	5.43726D 02	4.78421D 02	6.19261D 02	-2.31578D 03	3.04364D 03	1.80543D 04
13	16	-1.47775D 03	3.46930D 02	6.44413D 03	7.87020D 03	2.22618D 04	-2.46977D 04
13	25	-6.33075D 02	5.40920D 01	5.50794D 02	-1.05698D 03	-1.57574D 02	5.74120D 03
16	17	-1.07388D 04	4.54536D 01	-1.54174D 03	-5.40785D 02	6.56119D 04	-6.03902D 00
16	18	-9.14516D 03	-3.35619D 02	-7.45139D 02	2.40511D 03	9.17941D 04	-6.42475D 02
16	19	1.39666D 01	1.38939D 03	3.98859D 03	-1.02438D 04	-1.74917D 04	4.96372D 03
20	21	2.18345D 02	4.06634D 00	1.25766D 03	0.0	5.35874D 04	4.60846D 03
20	22	2.40153D 03	-4.68645D 02	-7.59145D 02	0.0	-5.75357D 03	5.64457D 04
21	23	5.67742D 02	1.65070D 03	-8.75012D 02	0.0	-9.44877D 03	-6.70096D 04
24	25	1.96612D 01	3.91656D 01	-3.58021D 02	5.52577D 02	-1.75696D 04	-4.69482D 02
10	26	-1.59971D 03	1.00185D 02	9.35485D 02	2.40589D 03	-2.97073D 04	-2.59889D 04
16	27	-6.51570D 02	6.01737D 02	-1.21864D 03	-1.52270D 03	6.79152D 04	-1.97089D 04
26	28	-2.63118D 03	-2.38661D 02	2.84217D 03	1.56744D 02	-2.01392D 04	-9.38070D 03
27	29	-5.51713D 02	1.94519D 03	4.72904D 02	-1.42643D 03	1.76344D 04	-9.36493D 03
26	30	-2.88971D 03	-1.70842D 01	1.70306D 03	4.56550D 02	-1.69294D 04	-1.16193D 04
27	31	-1.37896D 03	1.08051D 03	-7.36036D 01	-1.43408D 03	2.10007D 04	-5.13260D 03

IG(IJ),JG(IJ),VEE2(1,IJ),VEE2(2,IJ),VEE2(3,IJ),VEE2(4,IJ),VEE2(5,IJ),VEE2(6,IJ)

1	2	-1.10496D-02	-5.13914D-01	1.54478D 00	8.01663D-02	-4.26896D-02	-1.39368D-02
2	3	2.64514D-03	-3.10157D-01	1.31891D 00	2.80481D-03	-2.00488D-02	-5.84819D-03
3	4	-9.93140D-04	-3.69894D-02	8.86238D-02	-7.24521D-04	-5.82902D-03	-2.46959D-03
4	5	1.12049D-04	-4.10371D-02	2.66074D-02	7.75493D-07	-1.12386D-03	-1.72672D-03
4	7	-9.22864D-03	-1.96287D-01	2.74615D-02	-2.14842D-04	-3.60132D-04	-2.55350D-03
5	6	1.03077D-02	-4.36965D-02	4.99128D-02	-1.43593D-05	-4.26349D-03	-3.46974D-03
5	7	-5.83327D-03	-1.56767D-01	-3.43048D-02	6.79428D-04	7.77034D-04	-2.26852D-03
5	20	-2.03042D-02	-5.32173D 00	2.20492D-02	-6.56816D-02	-1.04433D-05	-7.58804D-02
5	21	-4.76021D-03	3.96851D 00	-4.51460D-05	7.60698D-02	-4.80877D-04	4.52255D-02
5	22	-2.69117D-03	-1.65051D-01	-1.94885D-01	-9.08477D-02	2.61239D-03	2.62266D-02
5	23	-6.85385D-02	-5.56477D-01	-1.65405D-01	7.36314D-02	9.49966D-04	-4.00649D-02
6	9	1.00716D-03	-1.51152D-01	2.30287D-01	-2.27082D-03	-1.35947D-02	-9.79987D-03
6	11	3.59617D-03	1.09798D-02	3.94831D-02	-2.03892D-03	-4.46969D-03	1.17672D-03
7	9	3.83313D-01	-5.27436D-02	-3.25849D-02	-7.82506D-03	-1.88066D-02	9.92646D-05
8	9	-5.75020D-01	-1.39609D-01	4.85580D-01	-3.73132D-02	-1.49294D-03	-6.87165D-03
10	11	2.96653D-03	-2.76449D-04	-6.20645D-02	-2.01370D-03	4.24096D-03	-8.00454D-04
10	14	-2.81411D-03	-1.27482D-01	-1.51038D 01	1.25171D-04	3.88199D-01	-2.73892D-03
10	15	-4.73871D-03	-7.32546D-01	-1.51030D 01	2.25567D-05	3.83881D-01	-2.16141D-02
10	22	-6.44568D-03	-5.39150D-02	-4.86412D-02	-8.13491D-02	2.84599D-03	-1.70355D-03
10	23	6.56114D-02	-2.43321D-01	2.97066D-02	6.99199D-02	5.75589D-04	-7.52778D-03
11	16	4.43176D-03	-1.61267D-02	-2.10420D-03	-9.60012D-03	3.35874D-02	-3.91361D-04
12	16	-1.44886D-03	4.00353D-02	-1.42248D 00	9.72932D-04	4.52625D-02	2.15312D-03
12	24	3.67136D-03	7.24734D-01	2.90166D-02	-7.76846D-03	-7.63703D-04	2.35668D-02
13	16	-8.31131D-04	-1.49319D-02	1.07341D 00	7.37601D-03	-3.42217D-02	-7.84778D-04
13	25	-4.27465D-03	1.57955D-01	3.01275D-02	-3.54574D-03	-8.39213D-04	5.47984D-03
16	17	-4.48009D-02	1.26541D-01	-1.51070D 01	-1.83693D-05	3.58208D-01	3.85022D-03
16	18	-3.81525D-02	-9.92362D-01	-1.51027D 01	8.13904D-05	3.81217D-01	-3.08071D-02
16	19	6.75950D-05	6.91439D-04	1.97339D-01	-9.55579D-03	-6.33076D-03	2.20407D-05
20	21	4.91214D-03	1.16141D-01	8.85390D-02	-1.16330D-02	-2.70415D-04	2.54864D-03
20	22	3.24224D-02	5.77680D-02	-1.84899D-01	9.76750D-03	4.68022D-03	2.36767D-03
21	23	7.66493D-03	-1.10949D-02	-1.88971D-01	1.48785D-03	4.49986D-03	-1.21295D-03
24	25	2.21160D-05	3.15674D-02	-8.55954D-01	8.43629D-03	-7.10826D-03	4.82549D-04
10	26	-1.99971D-01	-1.61317D-03	1.24501D-02	2.40589D-03	-3.09524D-03	-2.61502D-03
16	27	-2.17190D-02	4.08735D-03	-1.91696D-02	-1.52270D-03	6.98322D-03	-1.93002D-03
26	28	-2.14091D 00	-3.35826D-03	3.07430D-02	1.56744D-04	-2.32135D-03	-9.71653D-04
27	29	-4.48912D-01	1.87024D-02	2.99556D-03	-1.42643D-03	1.73348D-03	-7.49469D-04
26	30	-3.67647D 00	-1.34623D-03	1.89127D-02	4.58550D-04	-1.88206D-03	-1.17539D-03

Figure 85. (Continued)

```
 27  31     -1.754400D 00     1.039580D-02    -2.864750-03    -1.434080D-03     2.128710-03    -4.093020-04
I,SC(I,1),SC(I,2),SC(I,3)
      10      0.0               0.0             2.935400D 00
      11      0.0               0.0             2.606820 00
      12      0.0               C.0             4.211480-03
      13      0.0               0.0             3.273890 00
      14      0.0               0.0             2.108200-03
      15      0.0               0.0             2.944230-03
      16      0.0               0.0             1.453910 00
      17      0.0               0.0             6.593940-04
      18      0.0               0.0             8.759200-02
      22      0.0               0.0             2.007490 00
      23      0.0               0.0             3.791070 00

MASS       DRI
 30       2.408090 01
 31       1.149130 01
      RUPTURE SUMMARY

          I          J      TIME

         10         15    0.06786
         16         17    0.08624
         10         14    0.11572
         16         18    0.14320
```

Figure 85. (Continued)

RUN 31-52 DROP TEST CORRELATION 206/18G ENGINE 100

MASSES = 31 CP/DT = 100 DT =0.00002 TMAX = 0.160
XGDOT = 0.0 YGDOT = -2.232000 02 ZGDOT = 2.760000 02
P' = 4.6150CD-01 Q' = 0.0 R' = 0.0
PHI' = -1.746000-01 THETA' = -1.746000-02 PSI' = 0.0 ZG = 0.0

WEIGHTS

1	1.390000 02
2	8.500000 01
3	6.200000 01
4	1.720000 02
5	2.760000 02
6	9.320000 02
7	7.310000 02
8	1.412000 03
9	9.000000 01
10	2.570000 02
11	1.823000 03
12	1.750000 02
13	1.750000 02
14	2.400000 01
15	2.400000 01
16	9.500000 02
17	2.400000 01
18	2.400000 01
19	3.070000 02
20	3.100000 01
21	3.100000 01
22	1.660000 02
23	1.660000 02
24	2.850000 01
25	2.850000 01
26	5.500000 01
27	7.000000 01
28	1.200000 02
29	1.200000 02
30	1.200000 02
31	1.200000 02

I,IX(I),IY(I),IZ(I),IXY(I),IYZ(I),IXZ(I)

1	2.000000 02	1.730000 02	1.730000 02	0.0	0.0	0.0
2	1.000000 01	2.050000 02	2.000000 02	0.0	0.0	0.0
3	1.500000 01	1.470000 02	1.320000 02	0.0	0.0	0.0
4	3.400000 01	3.400000 01	1.000000 01	0.0	0.0	0.0
5	2.500000 02	2.500000 02	2.500000 02	0.0	0.0	0.0
6	1.000000 03	1.000000 03	1.000000 03	0.0	0.0	0.0
7	3.060000 02	6.030000 02	6.280000 02	0.0	0.0	0.0
8	3.500000 03	3.563000 03	3.130000 02	0.0	0.0	0.0
9	3.700000 01	4.700000 01	4.000000 01	0.0	0.0	0.0
10	2.500000 02	2.500000 02	2.500000 02	0.0	0.0	0.0
11	2.010000 03	5.082000 03	3.294000 03	0.0	0.0	0.0
12	4.300000 01	2.500000 02	2.300000 02	0.0	0.0	0.0
13	4.300000 01	2.500000 02	2.300000 02	0.0	0.0	0.0
14	3.570000 01	3.570000 01	2.400000 01	0.0	0.0	0.0
15	3.570000 01	3.570000 01	2.400000 01	0.0	0.0	0.0
16	1.000000 03	1.100000 03	1.100000 03	0.0	0.0	0.0
17	5.620000 01	5.620000 01	2.400000 01	0.0	0.0	0.0
18	5.620000 01	5.620000 01	2.400000 01	0.0	0.0	0.0
19	1.716000 02	2.476000 02	7.600000 01	0.0	0.0	0.0
20	1.284000 02	1.290000 02	3.960000 01	0.0	0.0	0.0
21	1.284000 02	1.290000 02	3.960000 01	0.0	0.0	0.0
22	6.650000 01	7.000000 01	7.000000 01	0.0	0.0	0.0

Figure 86. Input Data, Combined Vertical and Lateral Impact Sample Case.

23	4.650000D 01	7.000000D 01	7.000000D 01	0.0	0.0	0.0
24	1.358000D 02	2.688000D 02	1.565000D 02	0.0	0.0	0.0
25	1.358000D 02	2.688000D 02	1.565000D 02	0.0	0.0	0.0
26	1.800000D 02	1.800000D 02	1.800000D 02	0.0	0.0	0.0
27	1.800000D 02	1.800000D 02	1.800000D 02	0.0	0.0	0.0
28	1.800000D 02	1.800000D 02	1.800000D 02	0.0	0.0	0.0
29	1.800000D 02	1.800000D 02	1.800000D 02	0.0	0.0	0.0
30	1.800000D 02	1.800000D 02	1.800000D 02	0.0	0.0	0.0
31	1.800000D 02	1.800000D 02	1.800000D 02	0.0	0.0	0.0

I,X**(I),Y**(I),Z**(I)

1	4.587500D 02	0.0	1.325200D 02
2	4.042300D 02	0.0	7.200000D 01
3	2.412200D 02	0.0	4.750000D 01
4	2.116000D 02	0.0	3.845000D 01
5	1.630000D 02	0.0	3.845000D 01
6	1.410000D 02	0.0	3.845000D 01
7	1.870200D 02	0.0	7.880000D 01
8	1.365000D 02	0.0	9.000000D 01
9	1.410000D 02	0.0	6.706000D 01
10	1.630000D 02	0.0	2.200000D 01
11	1.410000D 02	0.0	2.200000D 01
12	7.163000D 01	-4.500000D 01	2.200000D 01
13	7.163000D 01	4.500000D 01	2.200000D 01
14	1.630000D 02	-5.080000D 01	-7.000000D 00
15	1.630000D 02	5.080000D 01	-7.000000D 00
16	7.162000D 01	0.0	2.200000D 01
17	7.162000D 01	-5.080000D 01	-7.000000D 00
18	7.162000D 01	5.080000D 01	-7.000000D 00
19	2.300000D 01	0.0	2.200000D 01
20	1.630000D 02	-4.500000D 01	7.600000D 01
21	1.630000D 02	4.500000D 01	7.600000D 01
22	1.630000D 02	-4.500000D 01	7.200000D 01
23	1.630000D 02	4.500000D 01	7.200000D 01
24	7.162000D 01	-4.500000D 01	7.600000D 01
25	7.162000D 01	4.500000D 01	7.600000D 01
26	1.630000D 02	0.0	3.200000D 01
27	7.162000D 01	0.0	3.200000D 01
28	1.630000D 02	0.0	4.200000D 01
29	7.162000D 01	0.0	4.200000D 01
30	1.630000D 02	0.0	4.200000D 01
31	7.162000D 01	0.0	4.200000D 01

THERE ARE 0 I'S HAVING NON-ZERO HE OR PHI**,THETA**,PSI**

THERE ARE 0 I'S HAVING NON-ZERO LC'S

I,K,LBAR(I,K),MU(I,K),KE(I,K)

10	3	1.700000D 01	3.000000D-01	3.300000D 04
11	3	1.700000D 01	3.000000D-01	1.100000D 04
12	3	1.700000D 01	3.000000D-01	1.100000D 04
13	3	1.700000D 01	3.000000D-01	1.100000D 04
14	3	2.250000D 00	3.000000D-01	2.200000D 04
15	3	2.250000D 00	3.000000D-01	2.200000D 04
16	3	1.700000D 01	3.000000D-01	3.300000D 04
17	3	2.250000D 00	3.000000D-01	2.200000D 04
18	3	2.250000D 00	3.000000D-01	2.200000D 04
22	3	1.700000D 01	3.000000D-01	1.100000D 04
23	3	1.700000D 01	3.000000D-01	1.100000D 04

I,K,SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPOI(I,K),FSPOF(I,K)

10	3	1.000000D-03	1.000000D 00	2.000000D 00	3.500000D 00	1.650000D 04	1.650000D 04
11	3	1.000000D-03	1.000000D 00	2.000000D 00	3.500000D 00	5.500000D 03	5.500000D 03
12	3	1.000000D-03	1.000000D 00	2.000000D 00	3.500000D 00	5.500000D 03	5.500000D 03
13	3	1.000000D-03	1.000000D 00	2.000000D 00	3.500000D 00	5.500000D 03	5.500000D 03
14	3	2.000000D-01	4.000000D-01	6.000000D-01	1.200000D 00	4.400000D 03	4.400000D 03

Figure 86. (Continued).

```
15  3   2.000000D-01   4.000000D-01   6.000000D-01   1.200000 00   4.400000 03   4.400000 03
16  3   1.000000D-03   1.000000D 00   2.000000D 00   3.500000 00   1.650000 04   1.650000 04
17  3   2.000000D-01   4.000000D-01   6.000000D-01   1.200000 00   4.400000 03   4.400000 03
18  3   2.000000D-01   4.000000D-01   6.000000D-01   1.200000 00   4.400000 03   4.400000 03
22  3   1.000000D-03   1.000000D 00   2.000000D 00   3.500000 00   5.500000 03   5.500000 03
23  3   1.000000D-03   1.000000D 00   2.000000D 00   3.500000 00   5.500000 03   5.500000 03

IJ,I,J,PHI(I,J),THETA(I,J),PSI(I,J) (INTERNAL BEAMS)
 1  1  2   0.0        0.0        0.0
 2  2  3   0.0        0.0        0.0
 3  3  4   0.0        0.0        0.0
 4  4  5   0.0        0.0        0.0
 5  4  7   0.0        0.0        0.0
 6  5  6   0.0        0.0        0.0
 7  5  7   0.0        0.0        0.0
 8  5 20   0.0        0.0        0.0
 9  5 21   0.0        0.0        0.0
10  5 22   0.0        0.0        0.0
11  5 23   0.0        0.0        0.0
12  6  9   0.0        0.0        0.0
13  6 11   0.0        0.0        0.0
14  7  9   0.0        0.0        0.0
15  8  9   0.0        0.0        0.0
16 10 11   0.0        0.0        0.0
17 10 14   0.0        0.0        0.0
18 10 15   0.0        0.0        0.0
19 10 22   0.0        0.0        0.0
20 10 23   0.0        0.0        0.0
21 11 16   0.0        0.0        0.0
22 12 16   0.0        0.0        0.0
23 12 24   0.0        0.0        0.0
24 13 16   0.0        0.0        0.0
25 13 25   0.0        0.0        0.0
26 16 17   0.0        0.0        0.0
27 16 18   0.0        0.0        0.0
28 16 19   0.0        0.0        0.0
29 20 21   0.0        0.0        0.0
30 20 22   0.0        0.0        0.0
31 21 23   0.0        0.0        0.0
32 24 25   0.0        0.0        0.0
33 10 26   0.0        0.0        0.0
34 16 27   0.0        0.0        0.0
35 26 28   0.0        0.0        0.0
36 27 29   0.0        0.0        0.0
37 26 30   0.0        0.0        0.0
38 27 31   0.0        0.0        0.0

I,J,K MATRIX FOR INTERNAL BEAM IJ
 1  2
   1.227700 05   0.0           0.0           0.0           0.0           0.0
   0.0           1.754000 03   0.0           0.0           0.0          -7.143900 04
   0.0           0.0           2.220000 03   0.0           9.040000 04   0.0
   0.0           0.0           0.0           0.0           0.0           0.0
   0.0           0.0           9.040000 04   0.0           4.910600 06   0.0
   0.0          -7.143900 04   0.0           0.0           0.0           3.879400 06
 2  3
   6.127500 04   0.0           0.0           0.0           0.0           0.0
   0.0           8.505000 03   0.0           0.0           0.0          -6.940000 05
   0.0           0.0           9.663000 03   0.0           7.885000 05   0.0
   0.0           0.0           0.0           2.464000 06   0.0           0.0
   0.0           0.0           7.885000 05   0.0           8.579000 07   0.0
   0.0          -6.940000 05   0.0           0.0           0.0           7.550000 07
 3  4
   3.228000 05   0.0           0.0           0.0           0.0           0.0
   0.0           1.213000 06   0.0           0.0           0.0          -1.879000 07
   0.0           0.0           1.634000 06   0.0           2.530000 07   0.0
```

Figure 86. (Continued).

```
 0.0          0.0          0.0          3.649000 07  0.0          0.0
 0.0          0.0          2.530000 07  0.0          5.226000 08  0.0
 0.0         -1.879000 07  0.0          0.0          0.0          3.881000 08
4 5
 2.101000 06  0.0          0.0          0.0          0.0          0.0
 0.0          8.957000 05  0.0          0.0          0.0         -2.132000 07
 0.0          0.0          4.773000 06  0.0          1.136000 08  0.0
 0.0          0.0          0.0          8.193000 10  0.0          0.0
 0.0          0.0          1.136000 08  0.0          3.605000 09  0.0
 0.0         -2.132000 07  0.0          0.0          0.0          6.765000 08
4 7
 5.650000 04  0.0          0.0          0.0          0.0          0.0
 0.0          1.120000 05  0.0          0.0          0.0         -2.640000 06
 0.0          0.0          1.120000 05  0.0          2.640000 06  0.0
 0.0          0.0          0.0          0.0          0.0          0.0
 0.0          0.0          2.640000 06  0.0          8.290000 07  0.0
 0.0         -2.640000 06  0.0          0.0          0.0          8.290000 07
5 6
 4.545000 05  0.0          0.0          0.0          0.0          0.0
 0.0          1.665000 06  0.0          0.0          0.0         -1.832000 07
 0.0          0.0          5.531000 06  0.0          6.084000 07  0.0
 0.0          0.0          0.0          8.924000 09  0.0          0.0
 0.0          0.0          6.084000 07  0.0          8.923000 08  0.0
 0.0         -1.832000 07  0.0          0.0          0.0          2.686000 08
5 7
 5.650000 04  0.0          0.0          0.0          0.0          0.0
 0.0          1.120000 05  0.0          0.0          0.0         -2.640000 06
 0.0          0.0          1.120000 05  0.0          2.640000 06  0.0
 0.0          0.0          0.0          0.0          0.0          0.0
 0.0          0.0          2.640000 06  0.0          8.290000 07  0.0
 0.0         -2.640000 06  0.0          0.0          0.0          8.290000 07
5 20
 1.600000 05  0.0          0.0          0.0          0.0          0.0
 0.0          0.0          0.0          0.0          0.0          0.0
 0.0          0.0          4.918000 04  0.0          1.537000 06  0.0
 0.0          0.0          0.0          0.0          0.0          0.0
 0.0          0.0          1.537000 06  0.0          6.401000 07  0.0
 0.0          0.0          0.0          0.0          0.0          0.0
5 21
 1.600000 05  0.0          0.0          0.0          0.0          0.0
 0.0          0.0          0.0          0.0          0.0          0.0
 0.0          0.0          4.918000 04  0.0          1.537000 06  0.0
 0.0          0.0          0.0          0.0          0.0          0.0
 0.0          0.0          1.537000 06  0.0          6.401000 07  0.0
 0.0          0.0          0.0          0.0          0.0          0.0
5 22
 1.756000 05  0.0          0.0          0.0          0.0          0.0
 0.0          0.0          0.0          0.0          0.0          0.0
 0.0          0.0          6.498000 04  0.0          1.850000 06  0.0
 0.0          0.0          0.0          0.0          0.0          0.0
 0.0          0.0          1.850000 06  0.0          7.024000 07  0.0
 0.0          0.0          0.0          0.0          0.0          0.0
5 23
 1.756000 05  0.0          0.0          0.0          0.0          0.0
 0.0          0.0          0.0          0.0          0.0          0.0
 0.0          0.0          6.498000 04  0.0          1.850000 06  0.0
 0.0          0.0          0.0          0.0          0.0          0.0
 0.0          0.0          1.850000 06  0.0          7.024000 07  0.0
 0.0          0.0          0.0          0.0          0.0          0.0
6 9
 3.040000 06  0.0          0.0          0.0          0.0          0.0
 0.0          4.010000 05  0.0          0.0          0.0         -5.780000 06
 0.0          0.0          3.258000 05  0.0          4.690000 06  0.0
 0.0          0.0          0.0          2.560000 07  0.0          0.0
 0.0          0.0          4.690000 06  0.0          8.950000 07  0.0
 0.0         -5.780000 06  0.0          0.0          0.0          1.104000 08
```

Figure 86. (Continued).

```
 6 11
   4.863060 06    0.0            0.0            0.0            0.0            0.0
   0.0            4.227000 06    0.0            0.0            0.0           -3.477000 07
   0.0            0.0            3.424000 06    0.0            2.816000 07    0.0
   0.0            0.0            0.0            8.267000 07    0.0            0.0
   0.0            0.0            2.816000 07    0.0            3.088000 08    0.0
   0.0           -3.477000 07    0.0            0.0            0.0            3.813000 08
 7  9
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            2.190000 06    0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
 8  9
   2.039000 06    0.0            0.0            0.0            0.0            0.0
   0.0            1.051000 05    0.0            0.0            0.0           -2.422000 06
   0.0            0.0            1.911000 04    0.0            4.404000 05    0.0
   0.0            0.0            0.0            2.256000 06    0.0            0.0
   0.0            0.0            4.404000 05    0.0            1.354000 07    0.0
   0.0           -2.422000 06    0.0            0.0            0.0            7.445000 07
10 11
   5.455000 05    0.0            0.0            0.0            0.0            0.0
   0.0            4.869000 05    0.0            0.0            0.0           -5.355000 06
   0.0            0.0            1.803000 05    0.0            1.983000 06    0.0
   0.0            0.0            0.0            2.368000 06    0.0            0.0
   0.0            0.0            1.983000 06    0.0            2.909000 07    0.0
   0.0           -5.355000 06    0.0            0.0            0.0            7.855000 07
10 14
   4.795000 05    0.0            0.0            0.0            0.0            0.0
   0.0            2.697000 03    0.0            0.0            0.0           -6.637000 04
   0.0            0.0            2.697000 03    0.0            6.637000 04    0.0
   0.0            0.0            0.0            5.587000 07    0.0            0.0
   0.0            0.0            6.637000 04    0.0            2.178000 06    0.0
   0.0           -6.637000 04    0.0            0.0            0.0            2.178000 06
10 15
   4.795000 05    0.0            0.0            0.0            0.0            0.0
   0.0            2.697000 03    0.0            0.0            0.0           -6.637000 04
   0.0            0.0            2.697000 03    0.0            6.637000 04    0.0
   0.0            0.0            0.0            5.587000 07    0.0            0.0
   0.0            0.0            6.637000 04    0.0            2.178000 06    0.0
   0.0           -6.637000 04    0.0            0.0            0.0            2.178000 06
10 22
   8.889000 04    0.0            0.0            0.0            0.0            0.0
   0.0            2.239000 04    0.0            0.0            0.0           -5.037000 05
   0.0            0.0            1.317000 05    0.0            2.963000 06    0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            2.963000 06    0.0            8.889000 07    0.0
   0.0           -5.037000 05    0.0            0.0            0.0            1.511000 07
10 23
   8.889000 04    0.0            0.0            0.0            0.0            0.0
   0.0            2.239000 04    0.0            0.0            0.0           -5.037000 05
   0.0            0.0            1.317000 05    0.0            2.963000 06    0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            2.963000 06    0.0            8.889000 07    0.0
   0.0           -5.037000 05    0.0            0.0            0.0            1.511000 07
11 16
   1.730000 05    0.0            0.0            0.0            0.0            0.0
   0.0            1.545000 06    0.0            0.0            0.0           -5.359000 07
   0.0            0.0            5.749000 03    0.0            1.994000 05    0.0
   0.0            0.0            0.0            7.509000 05    0.0            0.0
   0.0            0.0            1.994000 05    0.0            9.225000 06    0.0
   0.0           -5.359000 07    0.0            0.0            0.0            2.479000 09
12 16
   1.778000 06    0.0            0.0            0.0            0.0            0.0
   0.0            1.275000 05    0.0            0.0            0.0           -2.368000 06
```

Figure 86. (Continued).

0.0	0.0	2.123000 04	0.0	4.776000 05	0.0
0.0	0.0	0.0	1.067000 06	0.0	0.0
0.0	0.0	4.776000 05	0.0	1.433000 07	0.0
0.0	-2.868000 06	0.0	0.0	0.0	8.604000 07
12 24					
1.481000 05	0.0	0.0	0.0	0.0	0.0
0.0	5.411000 03	0.0	0.0	0.0	-1.461000 05
0.0	0.0	7.377000 04	0.0	1.992000 06	0.0
0.0	0.0	0.0	2.981000 05	0.0	0.0
0.0	0.0	1.992000 06	0.0	7.170000 07	0.0
0.0	-1.461000 05	0.0	0.0	0.0	5.259000 06
13 16					
1.778000 06	0.0	0.0	0.0	0.0	0.0
0.0	1.275000 05	0.0	0.0	0.0	-2.868000 06
0.0	0.0	2.123000 04	0.0	4.776000 05	0.0
0.0	0.0	0.0	1.067000 06	0.0	0.0
0.0	0.0	4.776000 05	0.0	1.433000 07	0.0
0.0	-2.868000 06	0.0	0.0	0.0	8.604000 07
13 25					
1.481000 05	0.0	0.0	0.0	0.0	0.0
0.0	5.411000 03	0.0	0.0	0.0	-1.461000 05
0.0	0.0	7.377000 04	0.0	1.992000 06	0.0
0.0	0.0	0.0	2.981000 05	0.0	0.0
0.0	0.0	1.992000 06	0.0	7.170000 07	0.0
0.0	-1.461000 05	0.0	0.0	0.0	5.259000 06
16 17					
2.397000 05	0.0	0.0	0.0	0.0	0.0
0.0	1.429000 03	0.0	0.0	0.0	-3.516000 04
0.0	0.0	1.429000 03	0.0	3.516000 04	0.0
0.0	0.0	0.0	2.946000 07	0.0	0.0
0.0	0.0	3.516000 04	0.0	1.154000 06	0.0
0.0	-3.516000 04	0.0	0.0	0.0	1.154000 06
16 18					
2.397000 05	0.0	0.0	0.0	0.0	0.0
0.0	1.429000 03	0.0	0.0	0.0	-3.516000 04
0.0	0.0	1.429000 03	0.0	3.516000 04	0.0
0.0	0.0	0.0	2.946000 07	0.0	0.0
0.0	0.0	3.516000 04	0.0	1.154000 06	0.0
0.0	-3.516000 04	0.0	0.0	0.0	1.154000 06
16 19					
2.057000 05	0.0	0.0	0.0	0.0	0.0
0.0	8.933000 06	0.0	0.0	0.0	-2.172000 08
0.0	0.0	9.188000 04	0.0	2.234000 06	0.0
0.0	0.0	0.0	1.072000 06	0.0	0.0
0.0	0.0	2.234000 06	0.0	7.240000 07	0.0
0.0	-2.172000 08	0.0	0.0	0.0	7.039000 09
20 21					
4.445000 04	0.0	0.0	0.0	0.0	0.0
0.0	2.800000 03	0.0	0.0	0.0	-1.260000 05
0.0	0.0	1.647000 04	0.0	7.410000 05	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	7.410000 05	0.0	4.445000 07	0.0
0.0	-1.260000 05	0.0	0.0	0.0	7.550000 06
20 22					
7.407000 04	0.0	0.0	0.0	0.0	0.0
0.0	7.621000 04	0.0	0.0	0.0	-2.058000 06
0.0	0.0	1.296000 04	0.0	3.498000 05	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	3.498000 05	0.0	1.259000 07	0.0
0.0	-2.058000 06	0.0	0.0	0.0	7.407000 07
21 23					
7.407000 04	0.0	0.0	0.0	0.0	0.0
0.0	7.621000 04	0.0	0.0	0.0	-2.058000 06
0.0	0.0	1.296000 04	0.0	3.498000 05	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	3.498000 05	0.0	1.259000 07	0.0

Figure 86. (Continued).

```
    0.0        -2.058000 06   0.0           0.0           0.0           7.407000 07
 24 25
    8.890000 05   0.0           0.0           0.0           0.0           0.0
    0.0           3.960000 03   0.0           0.0           0.0          -1.792000 05
    0.0           0.0           3.045000 02   0.0           1.370000 04   0.0
    0.0           0.0           0.0           6.550000 04   0.0           0.0
    0.0           0.0           1.370000 04   0.0           8.220000 06   0.0
    0.0          -1.792000 05   0.0           0.0           0.0           1.075000 07
 10 26
    1.000000 04   0.0           0.0           0.0           0.0           0.0
    0.0           1.000000 05   0.0           0.0           0.0          -1.000000 05
    0.0           0.0           1.000000 05   0.0           1.000000 05   0.0
    0.0           0.0           0.0           1.000000 06   0.0           0.0
    0.0           0.0           1.000000 05   0.0           1.000000 07   0.0
    0.0          -1.000000 05   0.0           0.0           0.0           1.000000 07
 16 27
    3.000000 04   0.0           0.0           0.0           0.0           0.0
    0.0           1.000000 05   0.0           0.0           0.0          -1.000000 05
    0.0           0.0           1.000000 05   0.0           1.000000 05   0.0
    0.0           0.0           0.0           1.000000 06   0.0           0.0
    0.0           0.0           1.000000 05   0.0           1.000000 07   0.0
    0.0          -1.000000 05   0.0           0.0           0.0           1.000000 07
 26 28
    1.229000 03   0.0           0.0           0.0           0.0           0.0
    0.0           1.000000 05   0.0           0.0           0.0          -1.000000 05
    0.0           0.0           1.000000 05   0.0           1.000000 05   0.0
    0.0           0.0           0.0           1.000000 06   0.0           0.0
    0.0           0.0           1.000000 05   0.0           1.000000 07   0.0
    0.0          -1.000000 05   0.0           0.0           0.0           1.000000 07
 27 29
    1.229000 03   0.0           0.0           0.0           0.0           0.0
    0.0           1.000000 05   0.0           0.0           0.0          -1.000000 05
    0.0           0.0           1.000000 05   0.0           1.000000 05   0.0
    0.0           0.0           0.0           1.000000 06   0.0           0.0
    0.0           0.0           1.000000 05   0.0           1.000000 07   0.0
    0.0          -1.000000 05   0.0           0.0           0.0           1.000000 07
 26 30
    7.860000 02   0.0           0.0           0.0           0.0           0.0
    0.0           1.000000 05   0.0           0.0           0.0          -1.000000 05
    0.0           0.0           1.000000 05   0.0           1.000000 05   0.0
    0.0           0.0           0.0           1.000000 06   0.0           0.0
    0.0           0.0           1.000000 05   0.0           1.000000 07   0.0
    0.0          -1.000000 05   0.0           0.0           0.0           1.000000 07
 27 31
    7.860000 02   0.0           0.0           0.0           0.0           0.0
    0.0           1.000000 05   0.0           0.0           0.0          -1.000000 05
    0.0           0.0           1.000000 05   0.0           1.000000 05   0.0
    0.0           0.0           0.0           1.000000 06   0.0           0.0
    0.0           0.0           1.000000 05   0.0           1.000000 07   0.0
    0.0          -1.000000 05   0.0           0.0           0.0           1.000000 07
 IJ,I,J,CBAR(I,J)
   1   1   2    5.000000-02
   2   2   3    5.000000-02
   3   3   4    5.000000-02
   4   4   5    5.000000-02
   5   4   7    5.000000-02
   6   5   6    5.000000-02
   7   5   7    5.000000-02
   8   5  20    5.000000-02
   9   5  21    5.000000-02
  10   5  22    1.000000-01
  11   5  23    1.000000-01
  12   6   9    5.000000-02
  13   6  11    1.000000-01
  14   7   9    5.000000-02
```

Figure 86. (Continued).

```
15  8  9    5.000000D-02
16 10 11    1.000000D-01
17 10 14    1.000000D-01
18 10 15    1.000000D-01
19 10 22    1.000000D-01
20 10 23    1.000000D-01
21 11 16    1.000000D-01
22 12 16    1.000000D-01
23 12 24    5.000000D-02
24 13 16    1.000000D-01
25 13 25    5.000000D-02
26 16 17    1.000000D-01
27 16 18    1.000000D-01
28 16 19    1.000000D-01
29 20 21    5.000000D-02
30 20 22    5.000000D-02
31 21 23    5.000000D-02
32 24 25    5.000000D-02
33 10 26    5.000000D-02
34 16 27    5.000000D-02
35 26 28    2.470000D-01
36 27 29    2.380000D-01
37 26 30    1.818000D-01
38 27 31    1.752000D-01

KR TABLE SPECS, I,J,L,NP
     2     3     2     6
     2     3     3     6
     2     3     5     6
     2     3     6     6
     4     7     1     6
     4     7     2     6
     4     7     3     6
     4     7     4     6
     4     7     5     6
     4     7     6     6
     5     7     1     6
     5     7     2     6
     5     7     3     6
     5     7     4     6
     5     7     5     6
     5     7     6     6
     8     9     1     6
     8     9     2     6
     8     9     3     6
     8     9     4     6
     8     9     5     6
     8     9     6     6
    10    14     1     6
    10    14     2     6
    10    14     3     6
    10    14     4     6
    10    14     5     6
    10    14     6     6
    10    15     1     6
    10    15     2     6
    10    15     3     6
    10    15     4     6
    10    15     5     6
    10    15     6     6
    16    17     1     6
    16    17     2     6
    16    17     3     6
    16    17     4     6
    16    17     5     6
    16    17     6     6
```

Figure 86. (Continued).

```
      16    18    1    6
      16    18    2    6
      16    18    3    6
      16    18    4    6
      16    18    5    6
      16    18    6    6

  KR TABLE FOR I,J,L =     2    3    2
     1     0.0             1.00000E 00
     2     2.00000E 00     1.00000E 00
     3     4.00000E 00    -1.00000E 00
     4     6.00000E 00    -1.00000E 00
     5     8.00000E 00    -1.00000E 00
     6     1.00000E 01    -1.00000E 00

  KR TABLE FOR I,J,L =     2    3    3
     1     0.0             1.00000E 00
     2     2.00000E 00     1.00000E 00
     3     4.00000E 00    -1.00000E 00
     4     6.00000E 00    -1.00000E 00
     5     8.00000E 00    -1.00000E 00
     6     1.00000E 01    -1.00000E 00

  KR TABLE FOR I,J,L =     2    3    5
     1     0.0             1.00000E 00
     2     1.00000E 00     1.00000E 00
     3     2.00000E 00     0.0
     4     3.00000E 00    -1.00000E 00
     5     4.00000E 00    -1.00000E 00
     6     5.00000E 00    -1.00000E 00

  KR TABLE FOR I,J,L =     2    3    6
     1     0.0             1.00000E 00
     2     1.00000E 00     1.00000E 00
     3     2.00000E 00     0.0
     4     3.00000E 00    -1.00000E 00
     5     4.00000E 00    -1.00000E 00
     6     5.00000E 00    -1.00000E 00

  KR TABLE FOR I,J,L =     4    7    1
     1     0.0             1.00000E 00
     2     1.00000E-01     1.00000E 00
     3     2.00000E-01    -7.00000E-01
     4     3.00000E-01    -7.00000E-01
     5     4.00000E-01     0.0
     6     5.00000E-01     0.0

  KR TABLE FOR I,J,L =     4    7    2
     1     0.0             1.00000E 00
     2     6.67000E-02     1.00000E 00
     3     1.33400E-01     1.00000E 00
     4     2.00100E-01     1.00000E 00
     5     2.66800E-01     0.0
     6     3.33500E-01     0.0

  KR TABLE FOR I,J,L =     4    7    3
     1     0.0             1.00000E 00
     2     6.67000E-02     1.00000E 00
     3     1.33400E-01     1.00000E 00
     4     2.00100E-01     1.00000E 00
     5     2.66800E-01     0.0
     6     3.33500E-01     0.0

  KR TABLE FOR I,J,L =     4    7    4
     1     0.0             1.00000E 00
     2     1.00000E-01     1.00000E 00
```

Figure 86. (Continued).

```
 3    2.00000E-01    1.00000E 00
 4    3.00000E-01    1.00000E 00
 5    4.00000E-01    0.0
 6    5.00000E-01    0.0

KR TABLE FOR I,J,L =    4    7    5
 1    0.0            1.00000E 00
 2    1.00000E-01    1.00000E 00
 3    2.00000E-01    1.00000E 00
 4    3.00000E-01    1.00000E 00
 5    4.00000E-01    0.0
 6    5.00000E-01    0.0

KR TABLE FOR I,J,L =    4    7    6
 1    0.0            1.00000E 00
 2    1.00000E-01    1.00000E 00
 3    2.00000E-01    1.00000E 00
 4    3.00000E-01    1.00000E 00
 5    4.00000E-01    0.0
 6    5.00000E-01    0.0

KR TABLE FOR I,J,L =    5    7    1
 1    0.0            1.00000E 00
 2    1.00000E-01    1.00000E 00
 3    2.00000E-01   -7.00000E-01
 4    3.00000E-01   -7.00000E-01
 5    4.00000E-01    0.0
 6    5.00000E-01    0.0

KR TABLE FOR I,J,L =    5    7    2
 1    0.0            1.00000E 00
 2    6.67000E-02    1.00000E 00
 3    1.33400E-01    1.00000E 00
 4    2.00100E-01    1.00000E 00
 5    2.66800E-01    0.0
 6    3.33500E-01    0.0

KR TABLE FOR I,J,L =    5    7    3
 1    0.0            1.00000E 00
 2    6.67000E-02    1.00000E 00
 3    1.33400E-01    1.00000E 00
 4    2.00100E-01    1.00000E 00
 5    2.66800E-01    0.0
 6    3.33500E-01    0.0

KR TABLE FOR I,J,L =    5    7    4
 1    0.0            1.00000E 00
 2    1.00000E-01    1.00000E 00
 3    2.00000E-01    1.00000E 00
 4    3.00000E-01    1.00000E 00
 5    4.00000E-01    0.0
 6    5.00000E-01    0.0

KR TABLE FOR I,J,L =    5    7    5
 1    0.0            1.00000E 00
 2    1.00000E-01    1.00000E 00
 3    2.00000E-01    1.00000E 00
 4    3.00000E-01    1.00000E 00
 5    4.00000E-01    0.0
 6    5.00000E-01    0.0

KR TABLE FOR I,J,L =    5    7    6
 1    0.0            1.00000E 00
 2    1.00000E-01    1.00000E 00
 3    2.00000E-01    1.00000E 00
 4    3.00000E-01    1.00000E 00
```

Figure 86. (Continued).

```
  5    4.00000E-01    0.0
  6    5.00000E-01    0.0

 KR TABLE FOR I,J,L =     8    9    1
  1    0.0            7.85000E-03
  2    4.80000E-01    7.85000E-03
  3    9.60000E-01    1.00000E 00
  4    1.44000E 00    1.00000E 00
  5    1.92000E 00    0.0
  6    2.40000E 00    0.0

 KR ABLE FOR I,J,L =      8    9    2
  1    0.0            1.00000E 00
  2    2.00000E-01    1.00000E 00
  3    4.00000E-01    1.00000E 00
  4    6.00000E-01    1.00000E 00
  5    8.00000E-01    0.0
  6    1.00000E 00    0.0

 KR TABLE FOR I,J,L =     8    9    3
  1    0.0            1.00000E 00
  2    2.00000E-01    1.00000E 00
  3    4.00000E-01    1.00000E 00
  4    6.00000E-01    1.00000E 00
  5    8.00000E-01    0.0
  6    1.00000E 00    0.0

 KR TABLE FOR I,J,L =     8    9    4
  1    0.0            1.00000E 00
  2    1.00000E-01    1.00000E 00
  3    2.00000E-01    1.00000E 00
  4    3.00000E-01    1.00000E 00
  5    4.00000E-01    0.0
  6    5.00000E-01    0.0

 KR TABLE FOR I,J,L =     8    9    5
  1    0.0            1.00000E 00
  2    5.00000E-03    1.00000E 00
  3    1.00000E-02    1.00000E 00
  4    1.50000E-02    1.00000E 00
  5    2.00000E-02    0.0
  6    2.50000E-02    0.0

 KR TABLE FOR I,J,L =     8    9    6
  1    0.0            1.00000E 00
  2    1.00000E-01    1.00000E 00
  3    2.00000E-01    1.00000E 00
  4    3.00000E-01    1.00000E 00
  5    4.00000E-01    0.0
  6    5.00000E-01    0.0

 KR TABLE FOR I,J,L =    10   14    1
  1    0.0            1.00000E 00
  2    5.00000E-01    1.00000E 00
  3    1.00000E 00    1.00000E 00
  4    1.50000E 00    1.00000E 00
  5    2.00000E 00   -3.33000E 00
  6    2.50000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    10   14    2
  1    0.0            1.00000E 00
  2    4.00000E 00    1.00000E 00
  3    8.00000E 00    1.00000E 00
  4    1.20000E 01    1.00000E 00
  5    1.60000E 01   -3.32000E 00
  6    2.00000E 01   -3.32000E 00
```

Figure 86. (Continued).

```
KR TABLE FOR I,J,L =   10   14    3
   1    0.0             1.00000E 00
   2    4.00000E 00     1.00000E 00
   3    8.00000E 00     1.00000E 00
   4    1.20000E 01     1.00000E 00
   5    1.60000E 01    -3.33000E 00
   6    2.00000E 01    -3.33000E 00

KR TABLE FOR I,J,L =   10   14    4
   1    0.0             1.00000E 00
   2    2.00000E-01     1.00000E 00
   3    4.00000E-01     1.00000E 00
   4    6.00000E-01     1.00000E 00
   5    8.00000E-01    -3.33000E 00
   6    1.00000E 00    -3.33000E 00

KR TABLE FOR I,J,L =   10   14    5
   1    0.0             1.00000E 00
   2    2.00000E-01     1.00000E 00
   3    4.00000E-01     1.00000E 00
   4    6.00000E-01     1.00000E 00
   5    8.00000E-01    -3.33000E 00
   6    1.00000E 00    -3.33000E 00

KR TABLE FOR I,J,L =   10   14    6
   1    0.0             1.00000E 00
   2    2.00000E-01     1.00000E 00
   3    4.00000E-01     1.00000E 00
   4    6.00000E-01     1.00000E 00
   5    8.00000E-01    -3.33000E 00
   6    1.00000E 00    -3.33000E 00

KR TABLE FOR I,J,L =   10   15    1
   1    0.0             1.00000E 00
   2    5.00000E-01     1.00000E 00
   3    1.00000E 00     1.00000E 00
   4    1.50000E 00     1.00000E 00
   5    2.00000E 00    -3.33000E 00
   6    2.50000E 00    -3.33000E 00

KR TABLE FOR I,J,L =   10   15    2
   1    0.0             1.00000E 00
   2    4.00000E 00     1.00000E 00
   3    8.00000E 00     1.00000E 00
   4    1.20000E 01     1.00000E 00
   5    1.60000E 01    -3.33000E 00
   6    2.00000E 01    -3.33000E 00

KR TABLE FOR I,J,L =   10   15    3
   1    0.0             1.00000E 00
   2    4.00000E 00     1.00000E 00
   3    8.00000E 00     1.00000E 00
   4    1.20000E 01     1.00000E 00
   5    1.60000E 01    -3.33000E 00
   6    2.00000E 01    -3.33000E 00

KR TABLE FOR I,J,L =   10   15    4
   1    0.0             1.00000E 00
   2    2.00000E-01     1.00000E 00
   3    4.00000E-01     1.00000E 00
   4    6.00000E-01     1.00000E 00
   5    8.00000E-01    -3.33000E 00
   6    1.00000E 00    -3.33000E 00

KR TABLE FOR I,J,L =   10   15    5
```

Figure 86. (Continued).

```
   1    0.0            1.00000E 00
   2    2.00000E-01    1.00000E 00
   3    4.00000E-01    1.00000E 00
   4    6.00000E-01    1.00000E 00
   5    8.00000E-01   -3.33000E 00
   6    1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =   10   15    6
   1    0.0            1.00000E 00
   2    2.00000E-01    1.00000E 00
   3    4.00000E-01    1.00000E 00
   4    6.00000E-01    1.00000E 00
   5    8.00000E-01   -3.33000E 00
   6    1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =   16   17    1
   1    0.0            1.00000E 00
   2    5.00000E-01    1.00000E 00
   3    1.00000E 00    1.00000E 00
   4    1.50000E 00    1.00000E 00
   5    2.00000E 00   -3.33000E 00
   6    2.50000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =   16   17    2
   1    0.0            1.00000E 00
   2    4.00000E 00    1.00000E 00
   3    8.00000E 00    1.00000E 00
   4    1.20000E 01    1.00000E 00
   5    1.60000E 01   -3.33000E 00
   6    2.00000E 01   -3.33000E 00

 KR TABLE FOR I,J,L =   16   17    3
   1    0.0            1.00000E 00
   2    4.00000E 00    1.00000E 00
   3    8.00000E 00    1.00000E 00
   4    1.20000E 01    1.00000E 00
   5    1.60000E 01   -3.33000E 00
   6    2.00000E 01   -3.33000E 00

 KR TABLE FOR I,J,L =   16   17    4
   1    0.0            1.00000E 00
   2    2.00000E-01    1.00000E 00
   3    4.00000E-01    1.00000E 00
   4    6.00000E-01    1.00000E 00
   5    8.00000E-01   -3.33000E 00
   6    1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =   16   17    5
   1    0.0            1.00000E 00
   2    2.00000E-01    1.00000E 00
   3    4.00000E-01    1.00000E 00
   4    6.00000E-01    1.00000E 00
   5    8.00000E-01   -3.33000E 00
   6    1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =   16   17    6
   1    0.0            1.00000E 00
   2    2.00000E-01    1.00000E 00
   3    4.00000E-01    1.00000E 00
   4    6.00000E-01    1.00000E 00
   5    8.00000E-01   -3.33000E 00
   6    1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =   16   18    1
   1    0.0            1.00000E 00
   2    5.00000E-01    1.00000E 00
```

Figure 86. (Continued).

```
   3     1.00000E 00     1.00000E 00
   4     1.50000E 00     1.00000E 00
   5     2.00000E 00    -3.33000E 00
   6     2.50000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    16   16    2
   1     0.0             1.00000E 00
   2     4.00000E 00     1.00000E 00
   3     8.00000E 00     1.00000E 00
   4     1.20000E 01     1.00000E 00
   5     1.60000E 01    -3.33000E 00
   6     2.00000E 01    -3.33000E 00

 KP TABLE FOR I,J,L =    16   18    3
   1     0.0             1.00000E 00
   2     4.00000E 00     1.00000E 00
   3     8.00000E 00     1.00000E 00
   4     1.20000E 01     1.00000E 00
   5     1.60000E 01    -3.33000E 00
   6     2.00000E 01    -3.33000E 00

 KR TABLE FOR I,J,L =    16   18    4
   1     0.0             1.00000E 00
   2     2.00000E-01     1.00000E 00
   3     4.00000E-01     1.00000E 00
   4     6.00000E-01     1.00000E 00
   5     8.00000E-01    -3.33000E 00
   6     1.00000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    16   18    5
   1     0.0             1.00000E 00
   2     2.00000E-01     1.00000E 00
   3     4.00000E-01     1.00000E 00
   4     6.00000E-01     1.00000E 00
   5     8.00000E-01    -3.33000E 00
   6     1.00000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    16   18    6
   1     0.0             1.00000E 00
   2     2.00000E-01     1.00000E 00
   3     4.00000E-01     1.00000E 00
   4     6.00000E-01     1.00000E 00
   5     8.00000E-01    -3.33000E 00
   6     1.00000E 00    -3.33000E 00

 IJ,I,J,VMAX(I,J,1-6)
   1  1  2    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   2  2  3    1.000000D 01   6.000000D 00   6.000000D 00   1.000000D 01   1.000000D 01   1.000000D 01
   3  3  4    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   4  4  5    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   5  4  7    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   6  5  6    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   7  5  7    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   8  5 20    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   9  5 21    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  10  5 22    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  11  5 23    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  12  6  9    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  13  6 11    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  14  7  9    1.000000D 00   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  15  8  9    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  16 10 11    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  17 10 14    1.000000D 01   1.000000D 01   1.510000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  18 10 15    1.000000D 01   1.000000D 01   1.510000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  19 10 22    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  20 10 23    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
```

Figure 86. (Continued).

```
21 11 16   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
22 12 16   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
23 12 24   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
24 13 16   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
25 13 25   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
26 16 17   1.000000 01   1.000000 01   1.510000 01   1.000000 01   1.000000 01   1.000000 01
27 16 18   1.000000 01   1.000000 01   1.510000 01   1.000000 01   1.000000 01   1.000000 01
28 16 19   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
29 20 21   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
30 20 22   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
31 21 23   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
32 24 25   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
33 10 26   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
34 16 27   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
35 26 28   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
36 27 29   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
37 26 30   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01
38 27 31   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01   1.000000 01

                          PLOT CARDS WHICH ARE NOT ALL BLANK

             1         2         3         4         5         6         7         8
    12345678901234567890123456789012345678901234567890123456789012345678901234567890

  5       11 1     1                                                            5005
  6       11 1     1                                                            5006
  8       11 11    1                                                            5008
  9       11 11    1          11  11                                            5009
 12          1111  1     11                                                     5012
 13     1 1       1                     11                                      5013
 14     1 1       1                                                             5014
 15     1 1       1                                                             5015
 25                                     11                                      5025

INDP =  0

                              DRI(IJ) INDICATORS

             1         2         3         4         5         6         7         8
    12345678901234567890123456789012345678901234567890123456789012345678901234567890

                                        11                                      7000

IJ,THEIJ(IJ),PSIIJ(IJ)
   1   -8.375070-01    0.0
   2   -1.491810-01    0.0
   3   -2.965290-01    0.0
   4    0.0            0.0
   5    1.023660 00    0.0
   6    0.0            0.0
   7    2.107750 00    0.0
   8    6.953940-01    1.570800 00
   9    6.953940-01   -1.570800 00
  10   -3.504650-01    1.570800 00
  11   -3.504650-01   -1.570800 00
  12    1.570800 00    0.0
  13   -1.570800 00    0.0
  14   -2.497790-01    0.0
  15   -1.764500 00    0.0
  16    0.0            0.0
  17   -5.187220-01    1.570800 00
  18   -5.187220-01   -1.570800 00
  19    0.0            1.570800 00
  20    0.0           -1.570800 00
  21    0.0            0.0
  22    0.0           -1.570570 00
```

Figure 86. (Continued).

23	1.570610 00	0.0
24	0.0	1.570570 00
25	1.570610 00	0.0
26	-5.187220-01	1.570800 00
27	-5.187220-01	-1.570800 00
28	0.0	0.0
29	0.0	-1.570800 00
30	-1.570800 00	0.0
31	-1.570800 00	0.0
32	0.0	-1.570800 00
33	1.570800 00	0.0
34	1.570800 00	0.0
35	1.570800 00	0.0
36	1.570800 00	0.0
37	1.570800 00	0.0
38	1.570800 00	0.0

Figure 86. (Continued).

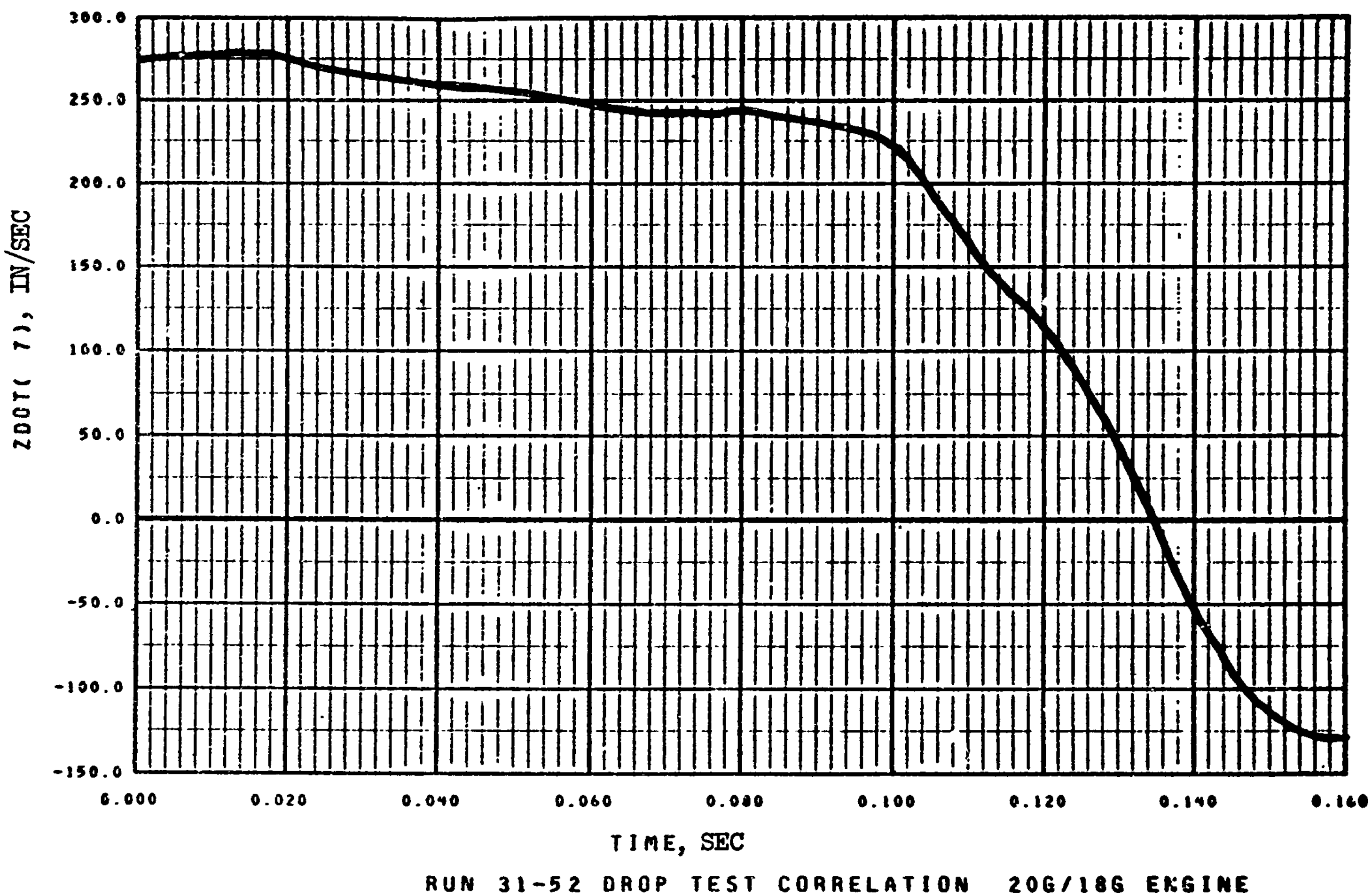


Figure 87. Engine Mass Vertical Velocity Time History Plot, Combined Vertical and Lateral Impact Sample Case.

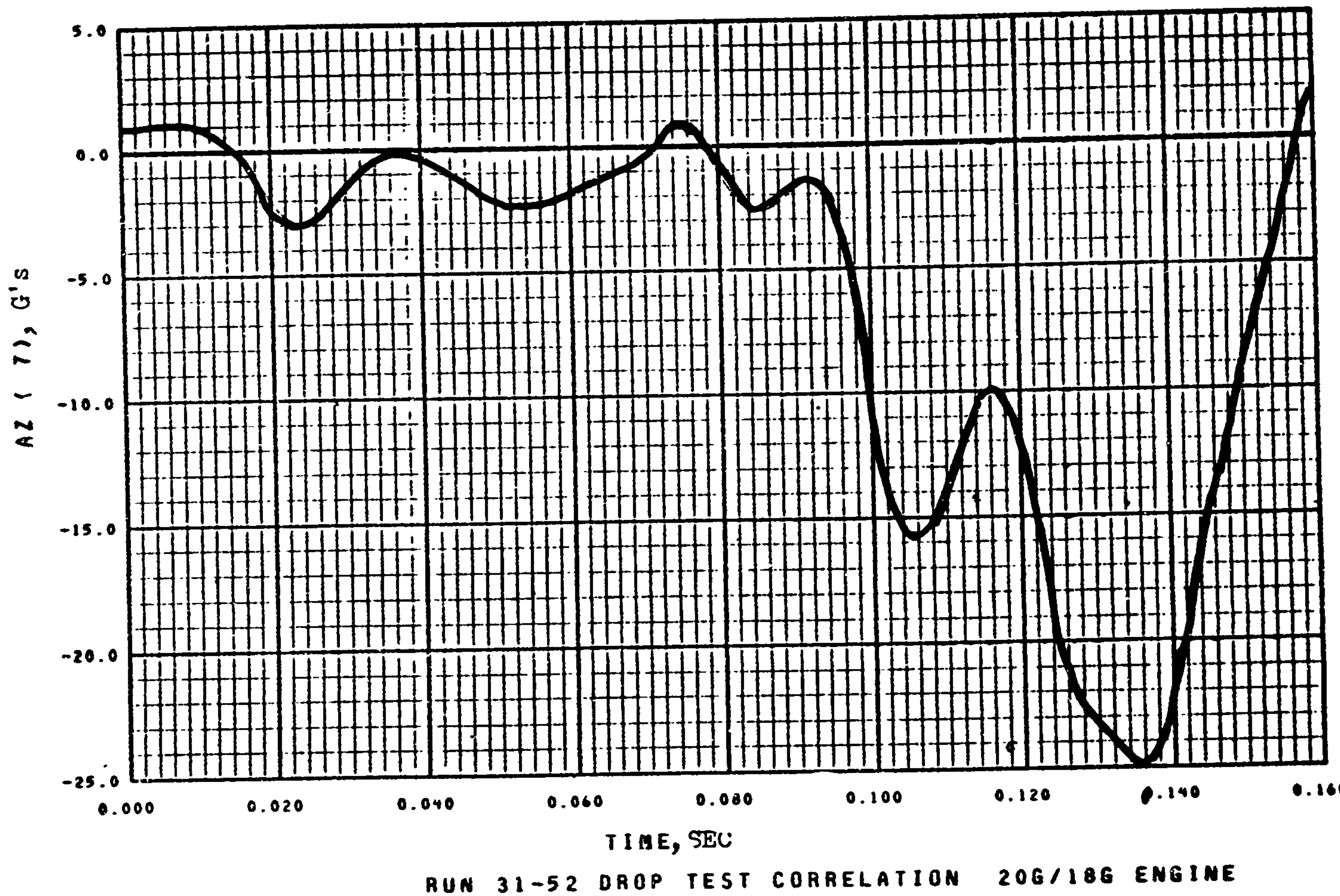


Figure 88. Engine Mass Vertical Acceleration Time History Plot, Combined Vertical and Lateral Impact Sample Case.

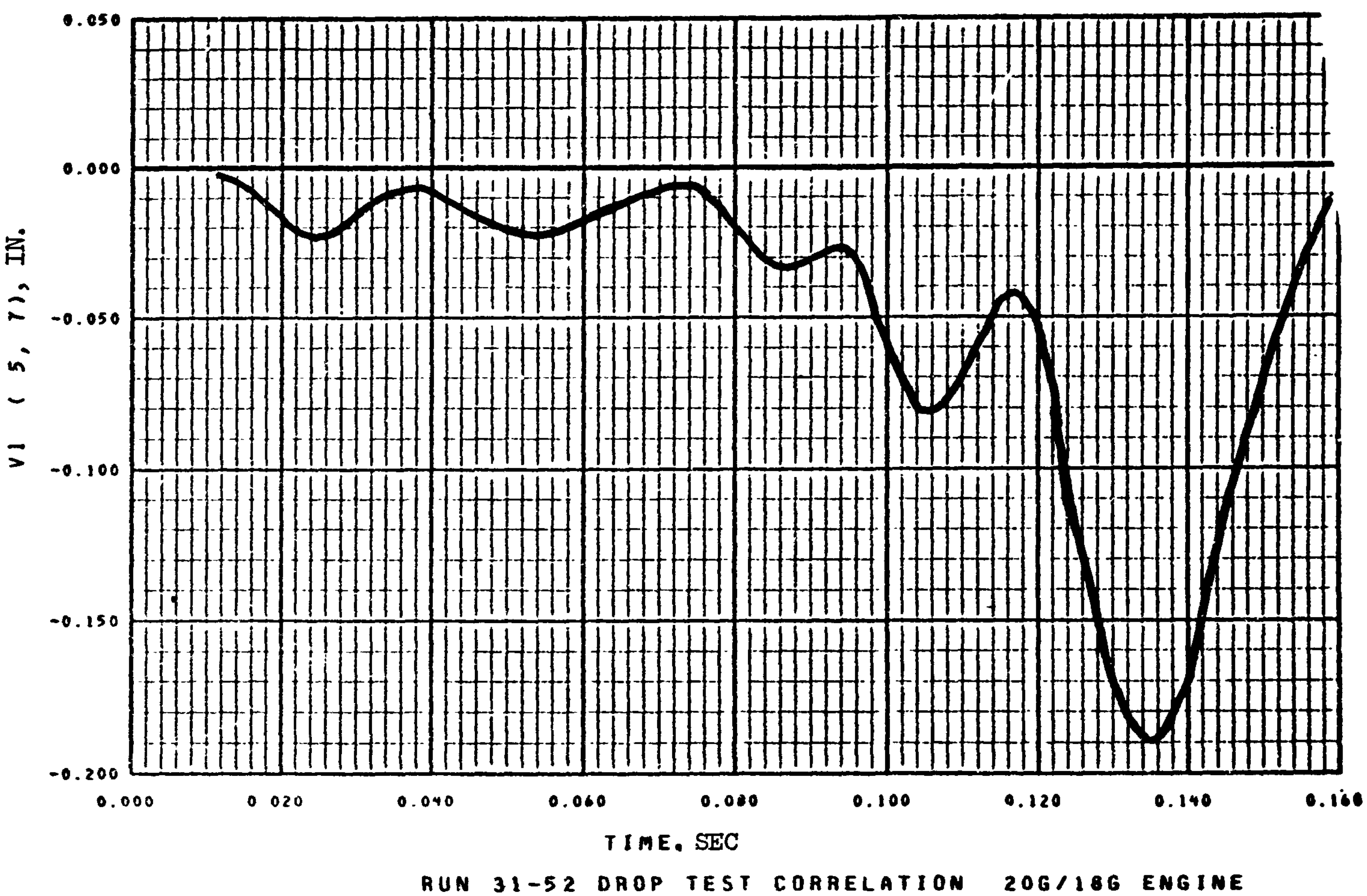


Figure 89. Engine Mount Vertical Deflection Time History Plot, Combined Vertical and Lateral Impact Sample Case.

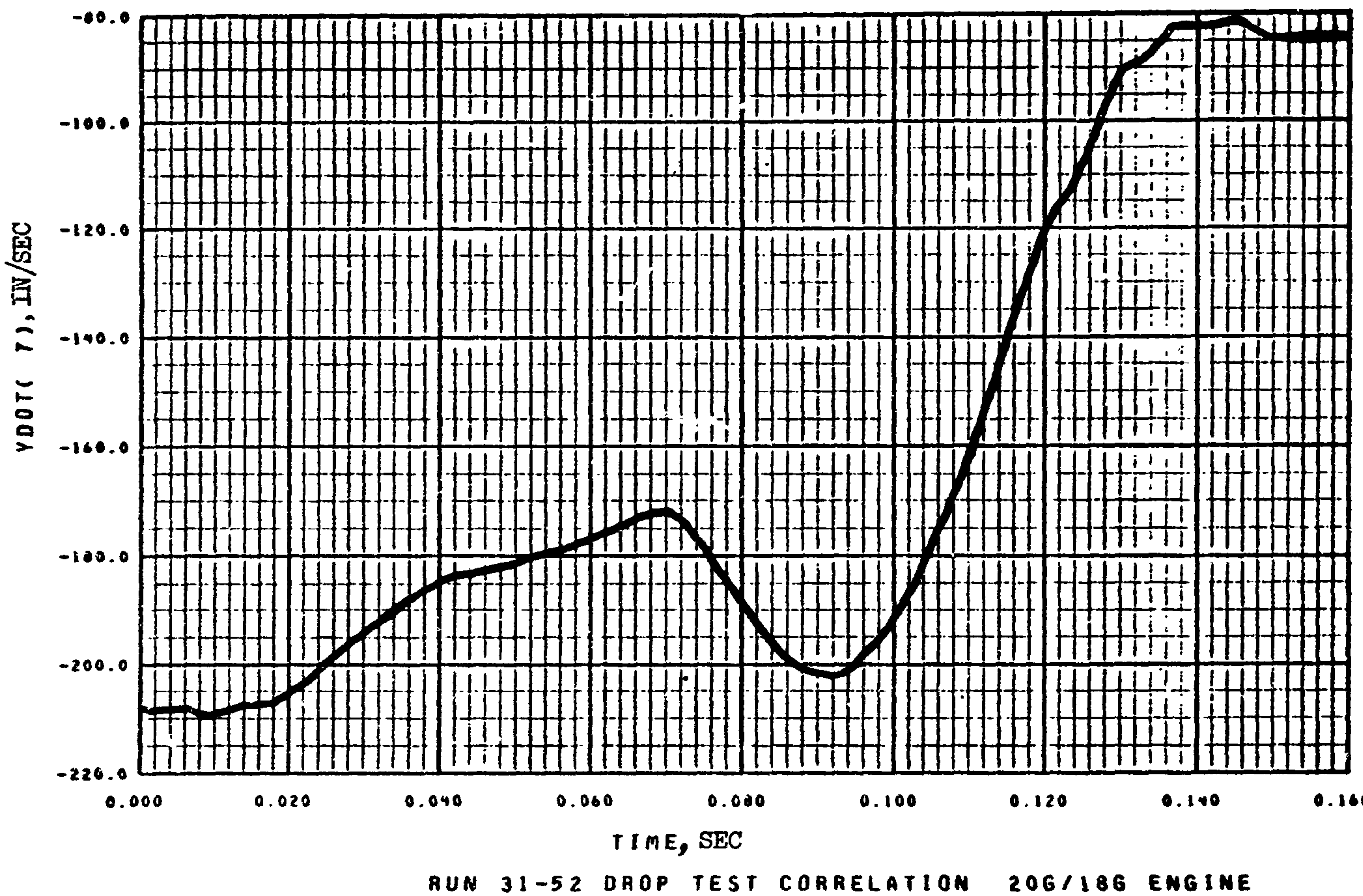


Figure 90. Engine Mass Lateral Velocity Time History Plot, Combined Vertical and Lateral Impact Sample Case.

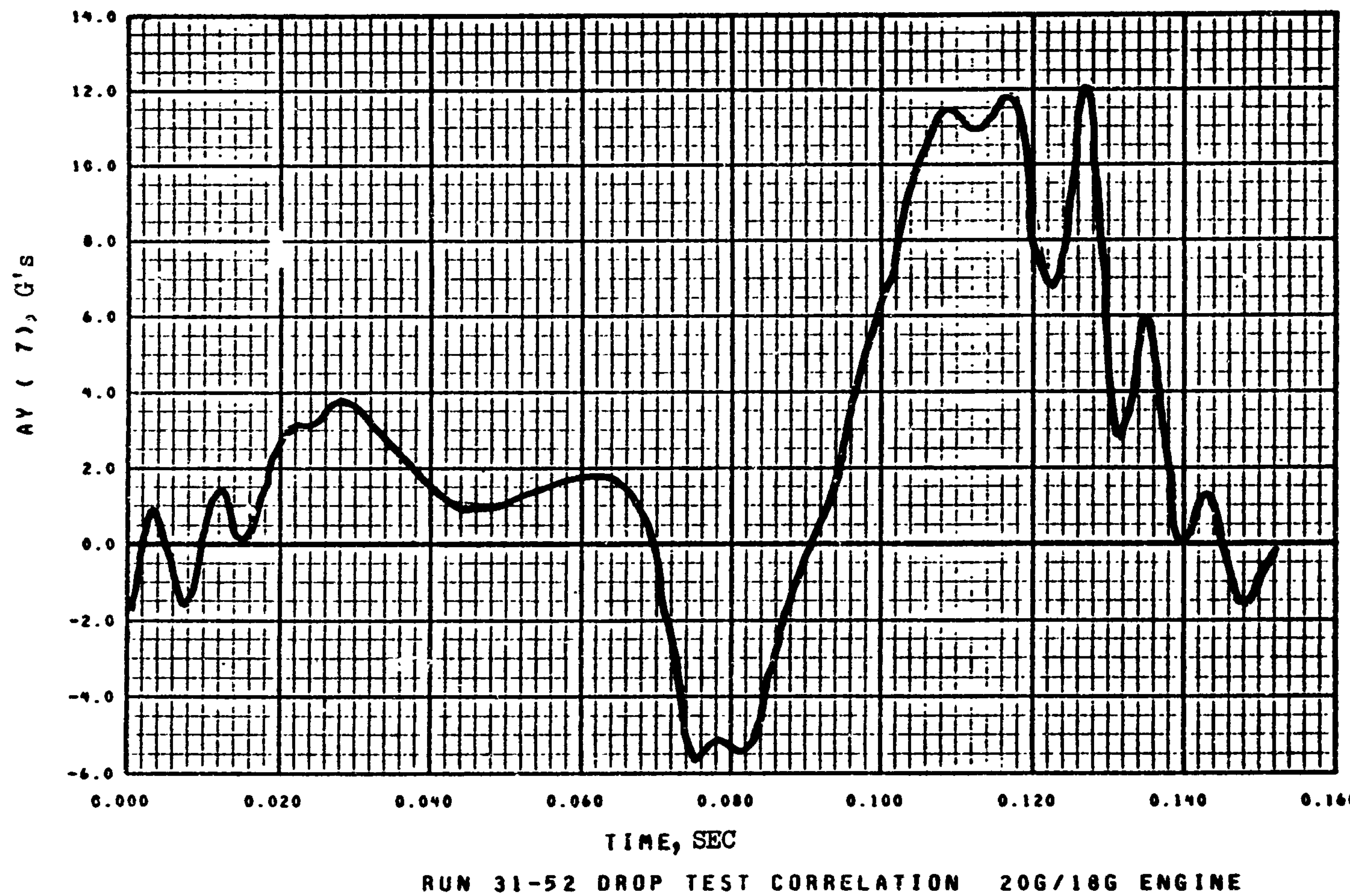


Figure 91. Engine Mass Lateral Acceleration Time History Plot, Combined Vertical and Lateral Impact Sample Case.

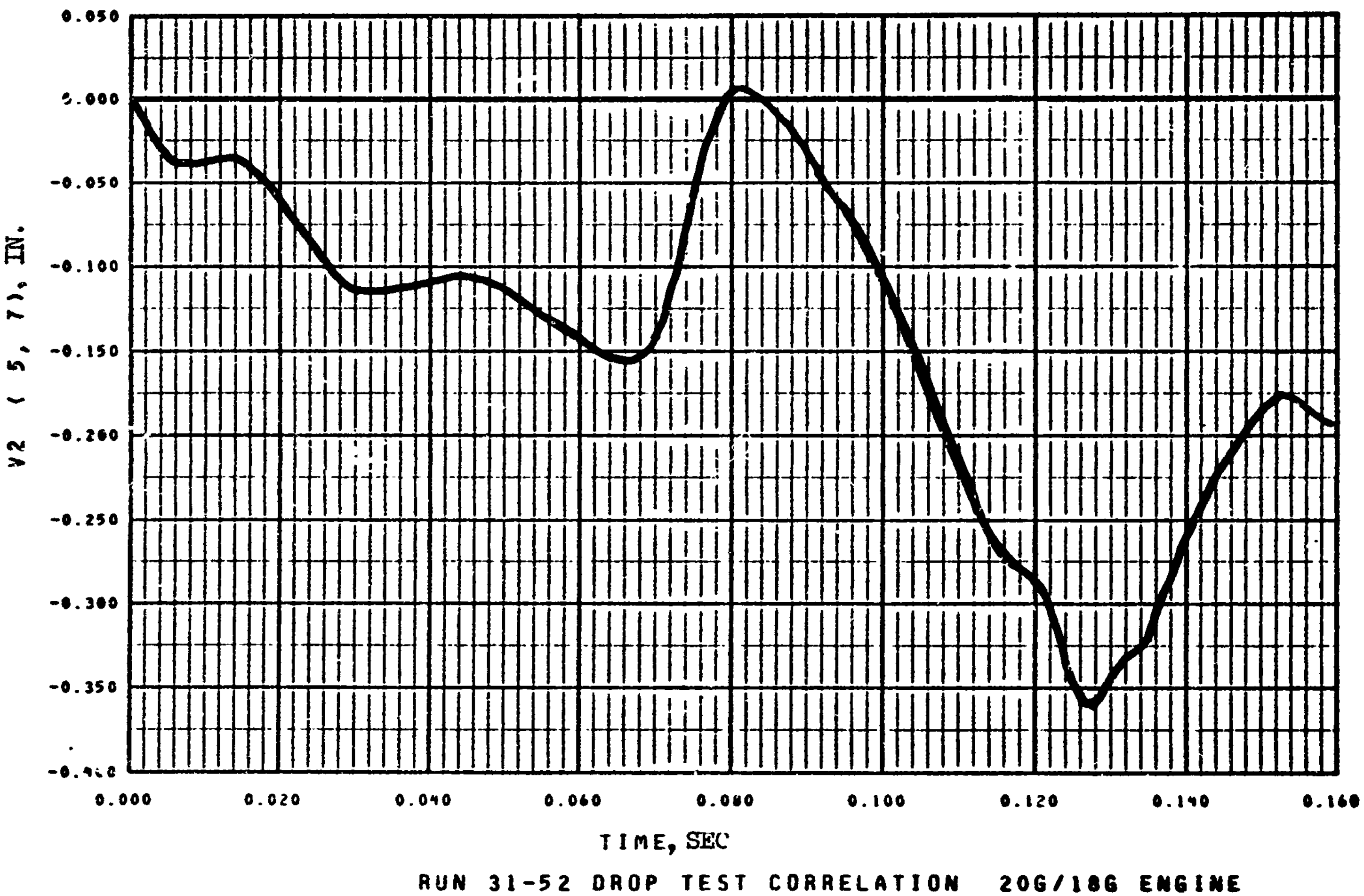


Figure 92. Engine Mount Lateral Deflection Time History Plot, Combined Vertical and Lateral Impact Sample Case.

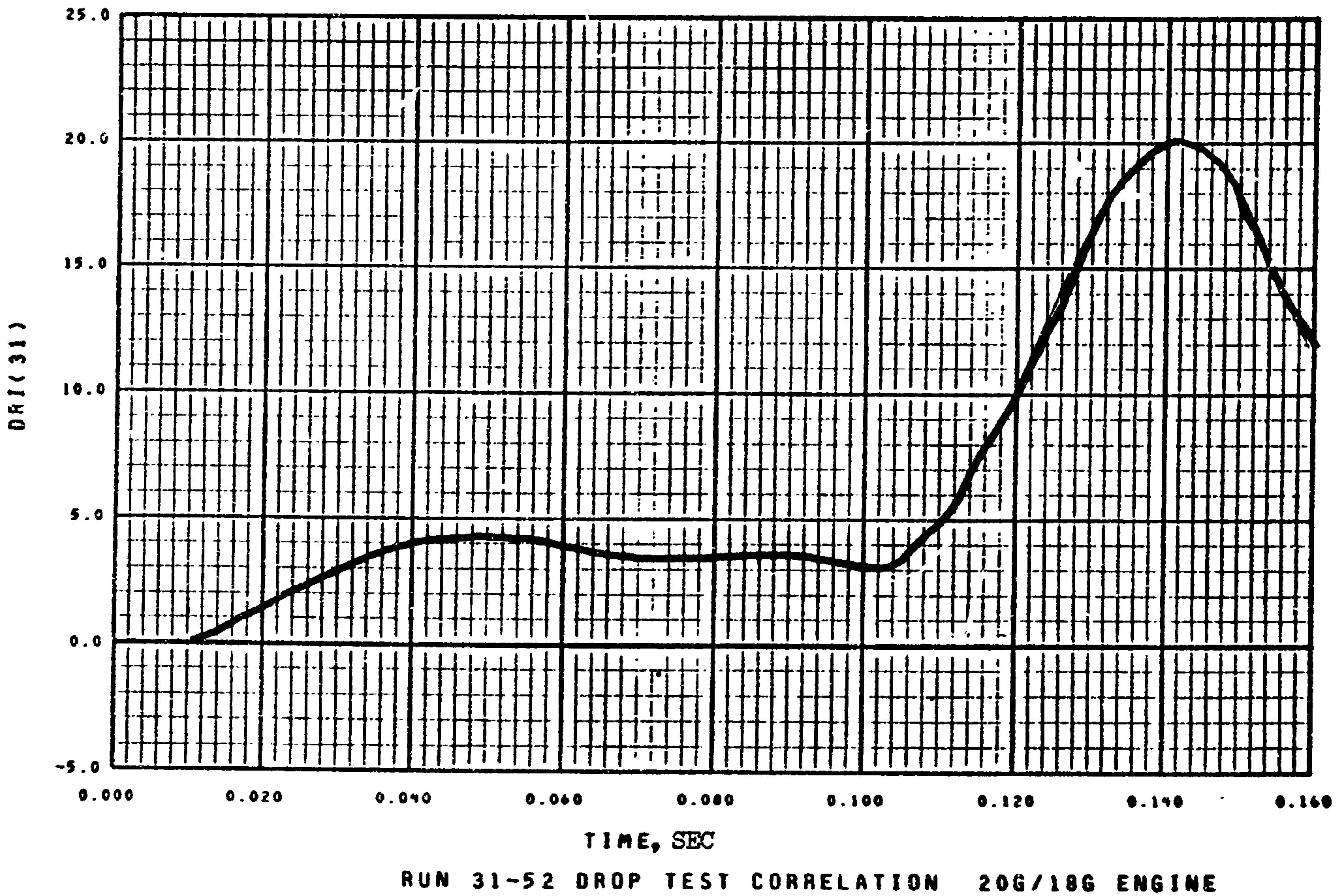


Figure 93. Forward DRI Time History Plot, Combined Vertical and Lateral Impact Sample Case.

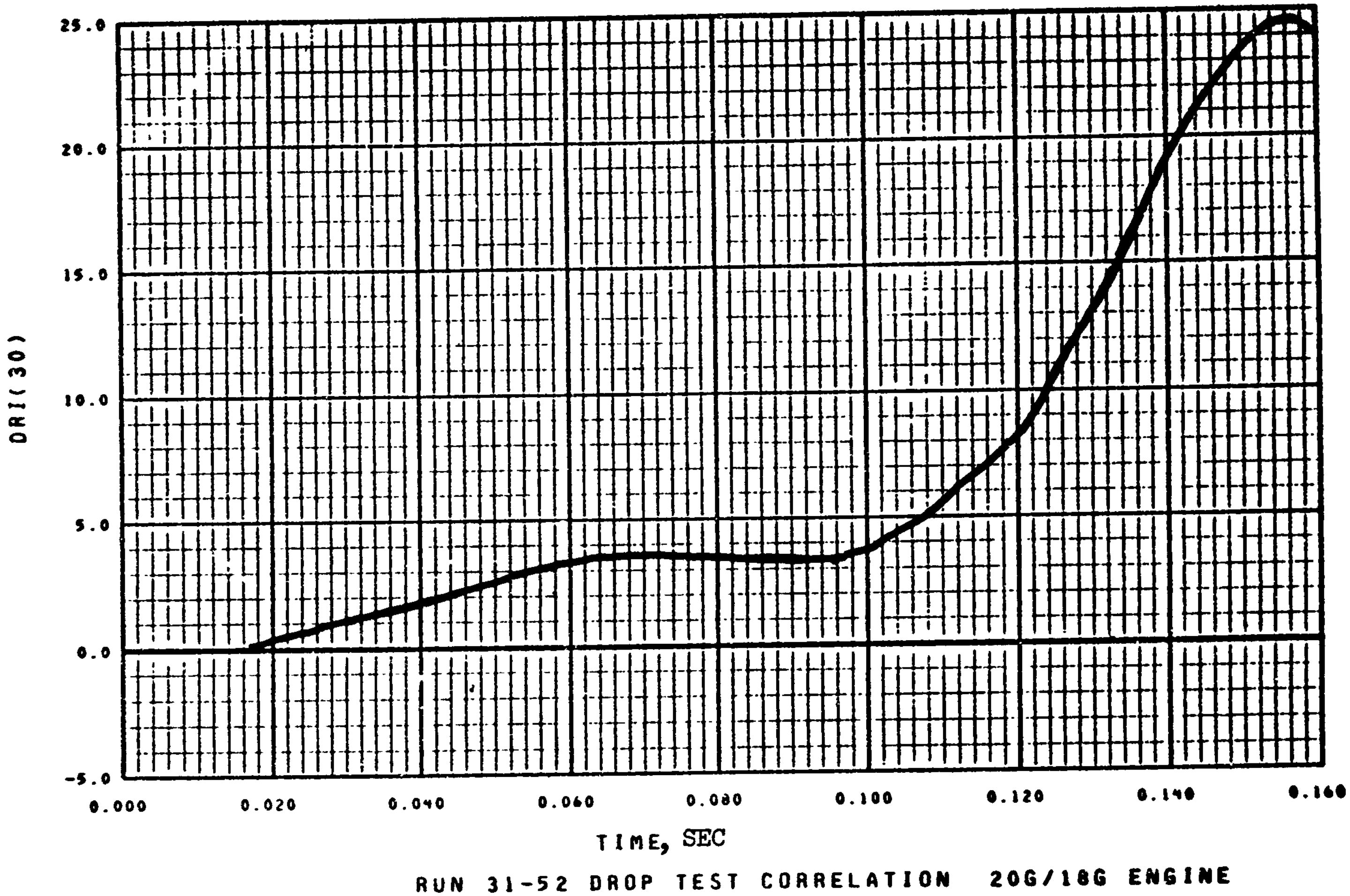


Figure 94. Aft DRI Time History Plot, Combined Vertical and Lateral Impact Sample Case.

```
RUN SE-31-100 COMBINED VEL. IMPACT                                   0100

MASSES = 32 DP/DT = 100 DT =0.00002 TMAX = 0.100
XGDOT =  3.240000 02  YGDOT = -2.232000 02  ZGDOT =  2.760000 02
    P' =  0.0            Q' =  0.0            R' =  0.0
  PHI' =  0.0        THETA' =  0.0          PSI' =  0.0           ZG =  0.0

WEIGHTS
   1    1.390000 02
   2    8.500000 01
   3    6.200000 01
   4    1.720000 02
   5    2.780000 02
   6    9.320000 02
   7    7.310000 02
   8    1.212000 03
   9    9.000000 01
  10    2.570000 02
  11    1.823000 03
  12    1.750000 02
  13    1.750000 02
  14    2.400000 01
  15    2.400000 01
  16    9.500000 02
  17    2.400000 01
  18    2.400000 01
  19    3.070000 02
  20    3.100000 01
  21    3.100000 01
  22    1.660000 02
  23    1.660000 02
  24    2.850000 01
  25    2.850000 01
  26    5.500000 01
  27    7.000000 01
  28    1.200000 02
  29    1.200000 02
  30    1.200000 02
  31    1.200000 02
  32    2.000000 02

I,IX(I),IY(I),IZ(I),IXY(I),IYZ(I),IXZ(I)
   1   2.000000 02   1.730000 02   1.730000 02   0.0   0.0   0.0
   2   1.000000 01   2.056000 02   2.000000 02   0.0   0.0   0.0
   3   1.500000 01   1.470000 02   1.320000 02   0.0   0.0   0.0
   4   3.400000 01   3.400000 01   1.000000 01   0.0   0.0   0.0
   5   2.500000 02   2.500000 02   2.500000 02   0.0   0.0   0.0
   6   1.000000 03   1.000000 03   1.000000 03   0.0   0.0   0.0
   7   3.060000 02   6.030000 02   6.280000 02   0.0   0.0   0.0
   8   3.500000 03   3.563000 03   3.130000 02   0.0   0.0   0.0
   9   3.700000 01   4.700000 01   4.000000 01   0.0   0.0   0.0
  10   2.500000 02   2.500000 02   2.500000 02   0.0   0.0   0.0
  11   7.010000 03   5.082000 03   3.294000 03   0.0   0.0   0.0
  12   4.300000 01   2.500000 02   2.300000 02   0.0   0.0   0.0
  13   4.300000 01   2.500000 02   2.300000 02   0.0   0.0   0.0
  14   3.570000 01   3.570000 01   2.400000 01   0.0   0.0   0.0
  15   3.570000 01   3.570000 01   2.400000 01   0.0   0.0   0.0
  16   1.000000 03   1.100000 03   1.100000 03   0.0   0.0   0.0
  17   5.620000 01   5.620000 01   2.400000 01   0.0   0.0   0.0
  18   5.620000 01   5.620000 01   2.400000 01   0.0   0.0   0.0
  19   1.716000 02   2.476000 02   7.600000 01   0.0   0.0   0.0
  20   1.284000 02   1.290000 02   3.960000 01   0.0   0.0   0.0
  21   1.284000 02   1.290000 02   3.960000 01   0.0   0.0   0.0
  22   4.650000 01   7.000000 01   7.000000 01   0.0   0.0   0.0
```

Figure 95. Input Data, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

23	4.650000 01	7.000000 01	7.000000 01	0.0	0.0	0.0
24	1.358000 02	2.688000 02	1.565000 02	0.0	0.0	0.0
25	1.358000 02	2.688000 02	1.565000 02	0.0	0.0	0.0
26	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
27	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
28	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
29	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
30	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
31	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
32	2.000000 01	2.000000 02	2.000000 02	0.0	0.0	0.0

I,X**(I),Y**(I),Z**(I)

1	4.587500 02	0.0	1.325200 02
2	4.042300 02	0.0	7.200000 01
3	2.412200 02	0.0	4.750000 01
4	2.116000 02	0.0	3.845000 01
5	1.630000 02	0.0	3.845000 01
6	1.410000 02	0.0	3.845000 01
7	1.870700 02	0.0	7.860000 01
8	1.356000 02	0.0	9.490000 01
9	1.410000 02	0.0	6.706000 01
10	1.630000 02	0.0	2.200000 01
11	1.410000 02	0.0	2.200000 01
12	7.163000 01	-4.500000 01	2.200000 01
13	7.163000 01	4.500000 01	2.200000 01
14	1.630000 02	-5.080000 01	-7.000000 00
15	1.630000 02	5.080000 01	-7.000000 00
16	7.162000 01	0.0	2.200000 01
17	7.162000 01	-5.080000 01	-7.000000 00
18	7.162000 01	5.080000 01	-7.000000 00
19	2.300000 01	0.0	2.200000 01
20	1.630000 02	-4.500000 01	7.600000 01
21	1.630000 02	4.500000 01	7.600000 01
22	1.630000 02	-4.500000 01	2.200000 01
23	1.630000 02	4.500000 01	2.200000 01
24	7.162000 01	-4.500000 01	7.600000 01
25	7.162000 01	4.500000 01	7.600000 01
26	1.630000 02	0.0	3.200000 01
27	7.162000 01	0.0	3.200000 01
28	1.630000 02	0.0	4.200000 01
29	7.162000 01	0.0	4.200000 01
30	1.630000 02	0.0	4.200000 01
31	7.162000 01	0.0	4.200000 01
32	5.000000 01	0.0	7.780000 01

THERE ARE 0 I'S HAVING NON-ZERO HE OR PHI**,THETA**,PSI**

THERE ARE 0 I'S HAVING NON-ZERO LC'S

I,K,LBAR(I,K),MU(I,K),KE(I,K)

10	3	1.700000 01	3.000000-01	3.300000 04
11	3	1.700000 01	3.000000-01	1.100000 04
12	3	1.700000 01	3.000000-01	1.100000 04
13	3	1.700000 01	3.000000-01	1.100000 04
14	3	2.250000 00	3.000000-01	2.200000 04
15	3	2.250000 00	3.000000-01	2.200000 04
16	3	1.700000 01	3.000000-01	3.300000 04
17	3	2.250000 00	3.000000-01	2.200000 04
18	3	2.250000 00	3.000000-01	2.200000 04
22	3	1.700000 01	3.000000-01	1.100000 04
23	3	1.700000 01	3.000000-01	1.100000 04

I,K,SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPDI(I,K),FSPDF(I,K)

10	3	1.000000-03	1.000000 00	2.000000 00	3.500000 00	1.550000 04	1.650000 04
11	3	1.000000-03	1.000000 00	2.000000 00	3.500000 00	5.500000 03	5.500000 03
12	3	1.000000-03	1.000000 00	2.000000 00	3.500000 00	5.500000 03	5.500000 03

Figure 95. (Continued).

13	3	1.000000D-03	1.000000D 00	2.000000D 00	3.500000D 00	5.500000D 03	5.500000D 03
14	3	2.000000D-01	4.000000D-01	6.000000D-01	1.200000D 00	4.400000D 03	4.400000D 03
15	3	2.000000D-01	4.000000D-01	6.000000D-01	1.200000D 00	4.400000D 03	4.400000D 03
16	3	1.000000D-03	1.000000D 00	2.000000D 00	3.500000D 00	1.650000D 04	1.650000D 04
17	3	2.000000D-01	4.000000D-01	6.000000D-01	1.200000D 00	4.400000D 03	4.400000D 03
18	3	2.000000D-01	4.000000D-01	6.000000D-01	1.200000D 00	4.400000D 03	4.400000D 03
22	3	1.000000D-03	1.000000D 00	2.000000D 00	3.500000D 00	5.500000D 03	5.500000D 03
23	3	1.000000D-03	1.000000D 00	2.000000D 00	3.500000D 00	5.500000D 03	5.500000D 03

IJ,I,J,PHI(I,J),THETA(I,J),PSI(I,J) (INTERNAL BEAMS)

IJ	I	J	PHI(I,J)	THETA(I,J)	PSI(I,J)
1	1	2	0.0	0.0	0.0
2	2	3	0.0	0.0	0.0
3	3	4	0.0	0.0	0.0
4	4	5	0.0	0.0	0.0
5	4	7	0.0	0.0	0.0
6	5	6	0.0	0.0	0.0
7	5	7	0.0	0.0	0.0
8	5	20	0.0	0.0	0.0
9	5	21	0.0	0.0	0.0
10	5	22	0.0	0.0	0.0
11	5	23	0.0	0.0	0.0
12	6	9	0.0	0.0	0.0
13	6	11	0.0	0.0	0.0
14	7	9	0.0	0.0	0.0
15	8	9	0.0	0.0	0.0
16	10	11	0.0	0.0	0.0
17	10	14	0.0	0.0	0.0
18	10	15	0.0	0.0	0.0
19	10	22	0.0	0.0	0.0
20	10	23	0.0	0.0	0.0
21	11	16	0.0	0.0	0.0
22	12	16	0.0	0.0	0.0
23	12	24	0.0	0.0	0.0
24	13	16	0.0	0.0	0.0
25	13	25	0.0	0.0	0.0
26	16	17	0.0	0.0	0.0
27	16	18	0.0	0.0	0.0
28	16	19	0.0	0.0	0.0
29	20	21	0.0	0.0	0.0
30	20	22	0.0	0.0	0.0
31	21	23	0.0	0.0	0.0
32	24	25	0.0	0.0	0.0
33	10	26	0.0	0.0	0.0
34	16	27	0.0	0.0	0.0
35	26	28	0.0	0.0	0.0
36	27	29	0.0	0.0	0.0
37	26	30	0.0	0.0	0.0
38	27	31	0.0	0.0	0.0
39	8	32	0.0	0.0	0.0

I,J,K-MATRIX FOR INTERNAL BEAM IJ

1 2

1.227700D 05	0.0	0.0	0.0	0.0	0.0
0.0	1.754000D 03	0.0	0.0	0.0	-7.143900D 04
0.0	0.0	2.220000D 03	0.0	9.040000D 04	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	9.040000D 04	0.0	4.910600D 06	0.0
0.0	-7.143900D 04	0.0	0.0	0.0	3.879400D 06

2 3

6.127500D 04	0.0	0.0	0.0	0.0	0.0
0.0	8.505000D 03	0.0	0.0	0.0	-6.940000D 05
0.0	0.0	9.663000D 03	0.0	7.885000D 05	0.0
0.0	0.0	0.0	2.464000D 06	0.0	0.0
0.0	0.0	7.885000D 05	0.0	8.579000D 07	0.0
0.0	-6.940000D 05	0 0	0.0	0.0	7.550000D 07

3 4

Figure 95. (Continued).

3.228000 05	0.0	0.0	0.0	0.0	0.0
0.0	1.213000 06	0.0	0.0	0.0	-1.879000 07
0.0	0.0	1.634000 06	0.0	2.530000 07	0.0
0.0	0.0	0.0	3.649000 07	0.0	0.0
0.0	0.0	2.530000 07	0.0	5.226000 08	0.0
0.0	-1.879000 07	0.0	0.0	0.0	3.881000 08
4 5					
2.101000 06	0.0	0.0	0.0	0.0	0.0
0.0	8.957000 05	0.0	0.0	0.0	-2.132000 07
0.0	0.0	4.773000 06	0.0	1.136000 08	0.0
0.0	0.0	0.0	8.193000 10	0.0	0.0
0.0	0.0	1.136000 08	0.0	3.605000 09	0.0
0.0	-2.132000 07	0.0	0.0	0.0	6.765000 08
4 7					
5.650000 04	0.0	0.0	0.0	0.0	0.0
0.0	1.120000 05	0.0	0.0	0.0	-2.640000 06
0.0	0.0	1.120000 05	0.0	2.640000 06	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	2.640000 06	0.0	8.290000 07	0.0
0.0	-2.640000 06	0.0	0.0	0.0	8.290000 07
5 6					
4.545000 05	0.0	0.0	0.0	0.0	0.0
0.0	1.665000 06	0.0	0.0	0.0	-1.832000 07
0.0	0.0	5.531000 06	0.0	6.084000 07	0.0
0.0	0.0	0.0	8.924000 09	0.0	0.0
0.0	0.0	6.084000 07	0.0	8.923000 08	0.0
0.0	-1.832060 07	0.0	0.0	0.0	2.686000 08
5 7					
5.650000 04	0.0	0.0	0.0	0.0	0.0
0.0	1.120000 05	0.0	0.0	0.0	-2.640000 06
0.0	0.0	1.120000 05	0.0	2.640000 06	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	2.640000 06	0.0	8.290000 07	0.0
0.0	-2.640000 06	0.0	0.0	0.0	8.290000 07
5 20					
1.600000 05	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	4.918000 04	0.0	1.537000 06	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.537000 06	0.0	6.401000 07	0.0
0.0	0.0	0.0	0.0	0.0	0.0
5 21					
1.600000 05	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	4.918000 04	0.0	1.537000 06	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.537000 06	0.0	6.401000 07	0.0
0.0	0.0	0.0	0.0	0.0	0.0
5 22					
1.756000 05	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	6.498000 04	0.0	1.850000 06	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.850000 06	0.0	7.024000 07	0.0
0.0	0.0	0.0	0.0	0.0	0.0
5 23					
1.756000 05	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	6.498000 04	0.0	1.850000 06	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.850000 06	0.0	7.024000 07	0.0
0.0	0.0	0.0	0.0	0.0	0.0
6 9					
3.040000 06	0.0	0.0	0.0	0.0	0.0
0.0	4.010000 05	0.0	0.0	0.0	-5.780000 06
0.0	0.0	3.258000 05	0.0	4.690000 06	0.0

Figure 95. (Continued).

0.0	0.0	0.0	2.56000D 07	0.0	0.0
0.0	0.0	4.69000D 06	0.0	8.95000D 07	0.0
0.0	-5.78000D 06	0.0	0.0	0.0	1.10400D 08
6 11					
4.86300D 06	0.0	0.0	0.0	0.0	0.0
0.0	4.22700D 06	0.0	0.0	0.0	-3.47700D 07
0.0	0.0	3.42400D 06	0.0	2.81600D 07	0.0
0.0	0.0	0.0	8.26700D 07	0.0	0.0
0.0	0.0	2.81600D 07	0.0	3.08900D 08	0.0
0.0	-3.47700D 07	0.0	0.0	0.0	3.81300D 08
7 9					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	2.19000D 06	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
8 9					
2.03900D 06	0.0	0.0	0.0	0.0	0.0
0.0	1.05100D 05	0.0	0.0	0.0	-2.42200D 06
0.0	0.0	1.91100D 04	0.0	4.40400D 05	0.0
0.0	0.0	0.0	2.25600D 06	0.0	0.0
0.0	0.0	4.40400D 05	0.0	1.35400D 07	0.0
0.0	-2.42200D 06	0.0	0.0	0.0	7.44500D 07
10 11					
5.45500D 05	0.0	0.0	0.0	0.0	0.0
0.0	4.86900D 05	0.0	0.0	0.0	-5.35500D 06
0.0	0.0	1.80300D 05	0.0	1.98300D 06	0.0
0.0	0.0	0.0	2.36800D 06	0.0	0.0
0.0	0.0	1.98300D 06	0.0	2.90900D 07	0.0
0.0	-5.35500D 06	0.0	0.0	0.0	7.85500D 07
10 14					
4.79500D 05	0.0	0.0	0.0	0.0	0.0
0.0	2.69700D 03	0.0	0.0	0.0	-6.63700D 04
0.0	0.0	2.69700D 03	0.0	6.63700D 04	0.0
0.0	0.0	0.0	5.58700D 07	0.0	0.0
0.0	0.0	6.63700D 04	0.0	2.17800D 04	0.0
0.0	-6.63700D 04	0.0	0.0	0.0	2.17800D 06
10 15					
4.79500D 05	0.0	0.0	0.0	0.0	0.0
0.0	2.69700D 03	0.0	0.0	0.0	-6.63700D 04
0.0	0.0	2.69700D 03	0.0	6.63700D 04	0.0
0.0	0.0	0.0	5.58700D 07	0.0	0.0
0.0	0.0	6.63700D 04	0.0	2.17800D 06	0.0
0.0	-6.63700D 04	0.0	0.0	0.0	2.17800D 06
10 22					
8.88900D 04	0.0	0.0	0.0	0.0	0.0
0.0	2.23900D 04	0.0	0.0	0.0	-5.03700D 05
0.0	0.0	1.31700D 05	0.0	2.96300D 06	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	2.96300D 06	0.0	8.88900D 07	0.0
0.0	-5.03700D 05	0.0	0.0	0.0	1.51100D 07
10 23					
8.88900D 04	0.0	0.0	0.0	0.0	0.0
0.0	2.23900D 04	0.0	0.0	0.0	-5.03700D 05
0.0	0.0	1.31700D 05	0.0	2.96300D 06	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	2.96300D 06	0.0	8.88900D 07	0.0
0.0	-5.03700D 05	0.0	0.0	0.0	1.51100D 07
11 16					
1.73000D 05	0.0	0.0	0.0	0.0	0.0
0.0	1.54500D 06	0.0	0.0	0.0	-5.35900D 07
0.0	0.0	5.74900D 03	0.0	1.99400D 05	0.0
0.0	0.0	0.0	7.50900D 05	0.0	0.0
0.0	0.0	1.99400D 05	0.0	9.22500D 04	0.0
0.0	-5.35900D 07	0.0	0.0	0.0	2.47900D 09

Figure 95. (Continued).

```
12 16
   1.778000 04   0.0           0.0           0.0           0.0           0.0
   0.0           1.275000 05   0.0           0.0           0.0          -2.868000 06
   0.0           0.0           2.123000 04   0.0           4.776000 05   0.0
   0.0           0.0           0.0           1.067000 06   0.0           0.0
   0.0           0.0           4.776000 05   0.0           1.433000 07   0.0
   0.0          -2.868000 06   0.0           0.0           0.0           8.604000 07
17 24
   1.481000 05   0.0           0.0           0.0           0.0           0.0
   0.0           5.411000 03   0.0           0.0           0.0          -1.461000 05
   0.0           0.0           7.377000 04   0.0           1.992000 06   0.0
   0.0           0.0           0.0           2.981000 05   0.0           0.0
   0.0           0.0           1.992000 06   0.0           7.170000 07   0.0
   0.0          -1.461000 05   0.0           0.0           0.0           5.259000 06
13 16
   1.778000 06   0.0           0.0           0.0           0.0           0.0
   0.0           1.275000 05   0.0           0.0           0.0          -2.868000 06
   0.0           0.0           2.123000 04   0.0           4.776000 05   0.0
   0.0           0.0           0.0           1.067000 06   0.0           0.0
   0.0           0.0           4.776000 05   0.0           1.433000 07   0.0
   0.0          -2.868000 06   0.0           0.0           0.0           8.604000 07
13 25
   1.481000 05   0.0           0.0           0.0           0.0           0.0
   0.0           5.411000 03   0.0           0.0           0.0          -1.461000 05
   0.0           0.0           7.377000 04   0.0           1.992000 06   0.0
   0.0           0.0           0.0           2.981000 05   0.0           0.0
   0.0           0.0           1.992000 06   0.0           7.170000 07   0.0
   0.0          -1.461000 05   0.0           0.0           0.0           5.259000 06
16 17
   2.397000 05   0.0           0.0           0.0           0.0           0.0
   0.0           1.429000 03   0.0           0.0           0.0          -3.516000 04
   0.0           0.0           1.429000 03   0.0           3.516000 04   0.0
   0.0           0.0           0.0           2.946000 07   0.0           0.0
   0.0           0.0           3.516000 04   0.0           1.154000 06   0.0
   0.0          -3.516000 04   0.0           0.0           0.0           1.154000 06
16 18
   2.397000 05   0.0           0.0           0.0           0.0           0.0
   0.0           1.429000 03   0.0           0.0           0.0          -3.516000 04
   0.0           0.0           1.429000 03   0.0           3.516000 04   0.0
   0.0           0.0           0.0           2.946000 07   0.0           0.0
   0.0           0.0           3.516000 04   0.0           1.154000 06   0.0
   0.0          -3.516000 04   0.0           0.0           0.0           1.154000 06
16 19
   2.057000 05   0.0           0.0           0.0           0.0           0.0
   0.0           8.933000 06   0.0           0.0           0.0          -2.172000 08
   0.0           0.0           9.188000 04   0.0           2.234000 06   0.0
   0.0           0.0           0.0           1.072000 06   0.0           0.0
   0.0           0.0           2.234000 06   0.0           7.240000 07   0.0
   0.0          -2.172000 08   0.0           0.0           0.0           7.039000 09
20 21
   4.445000 04   0.0           0.0           0.0           0.0           0.0
   0.0           2.800000 03   0.0           0.0           0.0          -1.260000 05
   0.0           0.0           1.647000 04   0.0           7.410000 05   0.0
   0.0           0.0           0.0           0.0           0.0           0.0
   0.0           0.0           7.410000 05   0.0           4.445000 07   0.0
   0.0          -1.260000 05   0.0           0.0           0.0           7.550000 06
20 22
   7.407000 04   0.0           0.0           0.0           0.0           0.0
   0.0           7.621000 04   0.0           0.0           0.0          -2.058000 06
   0.0           0.0           1.296000 04   0.0           3.498000 05   0.0
   0.0           0.0           0.0           0.0           0.0           0.0
   0.0           0.0           3.498000 05   0.0           1.259000 07   0.0
   0.0          -2.058000 06   0.0           0.0           0.0           7.407000 07
21 23
   7.407000 04   0.0           0.0           0.0           0.0           0.0
   0.0           7.621000 04   0.0           0.0           0.0          -2.058000 06
```

Figure 95. (Continued).

```
     0.0         0.0          1.296000 04  0.0          3.498000 05  0.0
     0.0         0.0          0.0          0.0          0.0          0.0
     0.0         0.0          3.498000 05  0.0          1.259000 07  0.0
     0.0        -2.058000 06  0.0          0.0          0.0          7.407000 07
  24 25
     8.890000 05 0.0          0.0          0.0          0.0          0.0
     0.0         3.980000 03  0.0          0.0          0.0         -1.792000 05
     0.0         0.0          3.045000 02  0.0          1.370000 04  0.0
     0.0         0.0          0.0          6.550000 04  0.0          0.0
     0.0         0.0          1.370000 04  0.0          8.220000 05  0.0
     0.0        -1.792000 05  0.0          0.0          0.0          1.075000 07
  10 26
     1.000000 04 0.0          0.0          0.0          0.0          0.0
     0.0         1.000000 05  0.0          0.0          0.0         -1.000000 05
     0.0         0.0          1.000000 05  0.0          1.000000 05  0.0
     0.0         0.0          0.0          1.000000 06  0.0          0.0
     0.0         0.0          1.000000 05  0.0          1.000000 07  0.0
     0.0        -1.000000 05  0.0          0.0          0.0          1.000000 07
  16 27
     3.000000 04 0.0          0.0          0.0          0.0          0.0
     0.0         1.000000 05  0.0          0.0          0.0         -1.000000 05
     0.0         0.0          1.000000 05  0.0          1.000000 05  0.0
     0.0         0.0          0.0          1.000000 06  0.0          0.0
     0.0         0.0          1.000000 05  0.0          1.000000 07  0.0
     0.0        -1.000000 05  0.0          0.0          0.0          1.000000 07
  26 28
     1.229000 03 0.0          0.0          0.0          0.0          0.0
     0.0         1.000000 05  0.0          0.0          0.0         -1.000000 05
     0.0         0.0          1.000000 05  0.0          1.000000 05  0.0
     0.0         0.0          0.0          1.000000 06  0.0          0.0
     0.0         0.0          1.000000 05  0.0          1.000000 07  0.0
     0.0        -1.000000 05  0.0          0.0          0.0          1.000000 07
  27 29
     1.229000 03 0.0          0.0          0.0          0.0          0.0
     0.0         1.000000 05  0.0          0.0          0.0         -1.000000 05
     0.0         0.0          1.000000 05  0.0          1.000000 05  0.0
     0.0         0.0          0.0          1.000000 06  0.0          0.0
     0.0         0.0          1.000000 05  0.0          1.000000 07  0.0
     0.0        -1.000000 05  0.0          0.0          0.0          1.000000 07
  26 30
     7.860000 02 0.0          0.0          0.0          0.0          0.0
     0.0         1.000000 05  0.0          0.0          0.0         -1.000000 05
     0.0         0.0          1.000000 05  0.0          1.000000 05  0.0
     0.0         0.0          0.0          1.000000 06  0.0          0.0
     0.0         0.0          1.000000 05  0.0          1.000000 07  0.0
     0.0        -1.000000 05  0.0          0.0          0.0          1.000000 07
  27 31
     7.860000 02 0.0          0.0          0.0          0.0          0.0
     0.0         1.000000 05  0.0          0.0          0.0         -1.000000 05
     0.0         0.0          1.000000 05  0.0          1.000000 05  0.0
     0.0         0.0          0.0          1.000000 06  0.0          0.0
     0.0         0.0          1.000000 05  0.0          1.000000 07  0.0
     0.0        -1.000000 05  0.0          0.0          0.0          1.000000 07
   8 32
     1.000000 05 0.0          0.0          0.0          0.0          0.0
     0.0         8.000000 03  0.0          0.0          0.0         -4.000000 05
     0.0         0.0          8.000000 03  0.0          4.000000 05  0.0
     0.0         0.0          0.0          1.000000 06  0.0          0.0
     0.0         0.0          4.000000 05  0.0          2.667000 07  0.0
     0.0        -4.000000 05  0.0          0.0          0.0          2.667000 07

IJ,I,J,CBAR(I,J)
  1  1  2    5.000000-02
  2  2  3    5.000000-02
  3  3  4    5.000000-02
  4  4  5    5.000000-02
```

Figure 95. (Continued).

5	4	7	5.000000-02
6	5	6	5.000000-02
7	5	7	5.000000-02
8	5	20	5.000000-02
9	5	21	5.000000-02
10	5	22	1.000000-01
11	5	23	1.000000-01
12	6	9	5.000000-02
13	6	11	1.000000-01
14	7	9	5.000000-02
15	8	9	5.000000-02
16	10	11	1.000000-01
17	10	14	1.000000-01
18	10	15	1.000000-01
19	10	22	1.000000-01
20	10	23	1.000000-01
21	11	16	1.000000-01
22	12	16	1.000000-01
23	12	24	5.000000-02
24	13	16	1.000000-01
25	13	25	5.000000-02
26	16	17	1.000000-01
27	16	18	1.000000-01
28	16	19	1.000000-01
29	20	21	5.000000-02
30	20	22	5.000000-02
31	21	23	5.000000-02
32	24	25	5.000000-02
33	10	26	5.000000-02
34	16	27	5.000000-02
35	26	28	2.470000-01
36	27	29	2.380000-01
37	26	30	1.818000-01
38	27	31	1.752000-01
39	8	32	5.000000-02

KR TABLE SPECS, I,J,L,NP

2	3	2	6
2	3	3	6
2	3	5	6
2	3	6	6
4	7	1	6
4	7	2	6
4	7	3	6
4	7	4	6
4	7	5	6
4	7	6	6
5	7	1	6
5	7	2	6
5	7	3	6
5	7	4	6
5	7	5	6
5	7	6	6
8	9	1	6
8	9	2	6
8	9	3	6
8	9	4	6
8	9	5	6
8	9	6	6
10	14	1	6
10	14	2	6
10	14	3	6
10	14	4	6
10	14	5	6
10	14	6	6
10	15	1	6

Figure 95. (Continued).

```
      10   15    2    6
      10   15    3    6
      10   15    4    6
      10   15    5    6
      10   15    6    6
      16   17    1    6
      16   17    2    6
      16   17    3    6
      16   17    4    6
      16   17    5    6
      16   17    6    6
      16   18    1    6
      16   18    2    6
      16   18    3    6
      16   18    4    6
      16   18    5    6
      16   18    6    6
  KR TABLE FOR I,J,L =     2    3    2
     1     0.0              1.00000E 00
     2     2.00000E 00      1.00000E 00
     3     4.00000E 00     -1.00000E 00
     4     6.00000E 00     -1.00000E 00
     5     8.00000E 00     -1.00000E 00
     6     1.00000E 01     -1.00000E 00

  KR TABLE FOR I,J,L =     2    3    3
     1     0.0              1.00000E 00
     2     2.00000E 00      1.00000E 00
     3     4.00000E 00     -1.00000E 00
     4     6.00000E 00     -1.00000E 00
     5     8.00000E 00     -1.00000E 00
     6     1.00000E 01     -1.00000E 00

  KR TABLE FOR I,J,L =     2    3    5
     1     0.0              1.00000E 00
     2     1.00000E 00      1.00000E 00
     3     2.00000E 00      0.0
     4     3.00000E 00     -1.00000E 00
     5     4.00000E 00     -1.00000E 00
     6     5.00000E 00     -1.00000E 00

  KR TABLE FOR I,J,L =     2    3    6
     1     0.0              1.00000E 00
     2     1.00000E 00      1.00000E 00
     3     2.00000E 00      0.0
     4     3.00000E 00     -1.00000E 00
     5     4.00000E 00     -1.00000E 00
     6     5.00000E 00     -1.00000E 0C

  KR TABLE FOR I,J,L =     4    7    1
     1     0.0              1.00000E 00
     2     1.00000E-01      1.00000E 00
     3     2.00000E-01     -7.00000E-01
     4     3.00000E-01     -7.00000E-01
     5     4.00000E-01      0.0
     6     5.00000E-01      0.0

  KR TABLE FOR I,J,L =     4    7    2
     1     0.0              1.00000E 00
     2     6.67000E-02      1.00000E 00
     3     1.33400E-01      1.00000E 00
     4     2.00100E-01      1.00000E 00
     5     2.66800E-01      0.0
     6     3.33500E-01      0.0
```

Figure 95. (Continued).

```
KR TABLE FOR I,J,L =     4     7     3
    1     0.0              1.00000E 00
    2     6.67000E-02      1.00000E 00
    3     1.33400E-01      1.00000E 00
    4     2.00100E-01      1.00000E 00
    5     2.66800E-01      0.0
    6     3.33500E-01      0.0

KR TABLE FOR I,J,L =     4     7     4
    1     0.0              1.00000E 00
    2     1.00000E-01      1.00000E 00
    3     2.00000E-01      1.00000E 00
    4     3.00000E-01      1.00000E 00
    5     4.00000E-01      0.0
    6     5.00000E-01      0.0

KR TABLE FOR I,J,L =     4     7     5
    1     0.0              1.00000E 00
    2     1.00000E-01      1.00000E 00
    3     2.00000E-01      1.00000E 00
    4     3.00000E-01      1.00000E 00
    5     4.00000E-01      0.0
    6     5.00000E-01      0.0

KR TABLE FOR I,J,L =     4     7     6
    1     0.0              1.00000E 00
    2     1.00000E-01      1.00000E 00
    3     2.00000E-01      1.00000E 00
    4     3.00000E-01      1.00000E 00
    5     4.00000E-01      0.0
    6     5.00000E-01      0.0

KR TABLE FOR I,J,L =     5     7     1
    1     0.0              1.00000E 00
    2     1.00000E-01      1.00000E 00
    3     2.00000E-01     -7.00000E-01
    4     3.00000E-01     -7.00000E-01
    5     4.00000E-01      0.0
    6     5.00000E-01      0.0

KR TABLE FOR I,J,L =     5     7     2
    1     0.0              1.00000E 00
    2     6.67000E-02      1.00000E 00
    3     1.33400E-01      1.00000E 00
    4     2.00100E-01      1.00000E 00
    5     2.66800E-01      0.0
    6     3.33500E-01      0.0

KR TABLE FOR I,J,L =     5     7     3
    1     0.0              1.00000E 00
    2     6.67000E-02      1.00000E 00
    3     1.33400E-01      1.00000E 00
    4     2.00100E-01      1.00000E 00
    5     2.66800E-01      0.0
    6     3.33500E-01      0.0

KR TABLE FOR I,J,L =     5     7     4
    1     0.0              1.00000E 00
    2     1.00000E-01      1.00000E 00
    3     2.00000E-01      1.00000E 00
    4     3.00000E-01      1.00000E 00
    5     4.00000E-01      0.0
    6     5.00000E-01      0.0

KR TABLE FOR I,J,L =     5     7     5
    1     0.0              1.00000E 00
```

Figure 95. (Continued)

```
  2     1.00000E-01     1.00000E 00
  3     2.00000E-01     1.00000E 00
  4     3.00000E-01     1.00000E 00
  5     4.00000E-01     0.0
  6     5.00000E-01     0.0

KR TABLE FOR I,J,L =     5    7    6
  1     0.0             1.00000E 00
  2     1.00000E-01     1.00000E 00
  3     2.00000E-01     1.00000E 00
  4     3.00000E-01     1.00000E 00
  5     4.00000E-01     0.0
  6     5.00000E-01     0.0

KR TABLE FOR I,J,L =     8    9    1
  1     0.0             7.85000E-03
  2     4.80000E-01     7.85000E-03
  3     9.60000E-01     1.00000E 00
  4     1.44000E 00     1.00000E 00
  5     1.92000E 00     0.0
  6     2.40000E 00     0.0

KR TABLE FOR I,J,L =     8    9    2
  1     0.0             1.00000E 00
  2     2.00000E-01     1.00000E 00
  3     4.00000E-01     1.00000E 00
  4     6.00000E-01     1.00000E 00
  5     8.00000E-01     0.0
  6     1.00000E 00     0.0

KR TABLE FOR I,J,L =     8    9    3
  1     0.0             1.00000E 00
  2     5.00000E-02     1.00000E 00
  3     1.00000E-0.     1.00000E 00
  4     1.50000E-01     1.00000E 00
  5     2.00000E-01     0.0
  6     2.50000E-01     0.0

KR TABLE FOR I,J,L =     8    9    4
  1     0.0             1.00000E 00
  2     1.00000E-01     1.00000E 00
  3     2.00000E-01     1.00000E 00
  4     3.00000E-01     2.00000E 00
  5     4.00000E-01     0.0
  6     5.00000E-01     0.0

KR TABLE FOR I,J,L =     8    9    5
  1     0.0             1.00000E 00
  2     1.00000E-03     1.00000E 00
  3     2.00000E-03     1.00000E 00
  4     3.00000E-03     1.00000E 00
  5     4.00000E-03     0.0
  6     5.00000E-03     0.0

KR TABLE FOR I,J,L =     8    9    6
  1     0.0             1.00000E 00
  2     1.00000E-01     1.00000E 00
  3     2.00000E-01     1.00000E 00
  4     3.00000E-01     1.00000E 00
  5     4.00000E-01     0.0
  6     5.00000E-01     0.0

KR TABLE FOR I,J,L =    10   14    1
  1     0.0             1.00000E 00
  2     5.00000E-01     1.00000E 00
  3     1.00000E 00     1.00000E 00
```

Figure 95. (Continued).

```
  4     1.50000E 00     1.00000E 00
  5     2.00000E 00    -3.33000E 00
  6     2.50000E 00    -3.33000E 00

KR TABLE FOR I,J,L =    10    14     2
  1     0.0             1.00000E 00
  2     4.00000E 00     1.00000E 00
  3     8.00000E 00     1.00000E 00
  4     1.20000E 01     1.00000E 00
  5     1.60000E 01    -3.33000E 00
  6     2.00000E 01    -3.33000E 00

KR TABLE FOR I,J,L =    10    14     3
  1     0.0             1.00000E 00
  2     4.00000E 00     1.00000E 00
  3     8.00000E 00     1.00000E 00
  4     1.20000E 01     1.00000E 00
  5     1.60000E 01    -3.33000E 00
  6     2.00000E 01    -3.33000E 00

KR TABLE FOR I,J,L =    10    14     4
  1     0.0             1.00000E 00
  2     2.00000E-01     1.00000E 00
  3     4.00000E-01     1.00000E 00
  4     6.00000E-01     1.00000E 00
  5     8.00000E-01    -3.33000E 00
  6     1.00000E 00    -3.33000E 00

KR TABLE FOR I,J,L =    10    14     5
  1     0.0             1.00000E 00
  2     2.00000E-01     1.00000E 00
  3     4.00000E-01     1.00000E 00
  4     6.00000E-01     1.00000E 00
  5     8.00000E-01    -3.33000E 00
  6     1.00000E 00    -3.33000E 00

KR TABLE FOR I,J,L =    10    14     6
  1     0.0             1.00000E 00
  2     2.00000E-01     1.00000E 00
  3     4.00000E-01     1.00000E 00
  4     6.00000E-01     1.00000E 00
  5     8.00000E-01    -3.33000E 00
  6     1.00000E 00    -3.33000E 00

KR TABLE FOR I,J,L =    10    15     1
  1     0.0             1.00000E 00
  2     5.00000E-01     1.00000E 00
  3     1.00000E 00     1.00000E 00
  4     1.50000E 00     1.00000E 00
  5     2.00000E 00    -3.33000E 00
  6     2.50000E 00    -3.33000E 00

KR TABLE FOR I,J,L =    10    15     2
  1     0.0             1.00000E 00
  2     4.00000E 00     1.00000E 00
  3     8.00000E 00     1.00000E 00
  4     1.20000E 01     1.00000E 00
  5     1.60000E 01    -3.33000E 00
  6     2.00000E 01    -3.33000E 00

KR TABLE FOR I,J,L =    10    15     3
  1     0.0             1.00000E 00
  2     4.00000E 00     1.00000E 00
  3     8.00000E 00     1.00000E 00
  4     1.20000E 01     1.00000E 00
  5     1.60000E 01    -3.33000E 00
```

Figure 95. (Continued).

```
  6     2.00000E 01    -3.33000E 00

 KR TABLE FOR I,J,L =    10   15    4
  1     0.0             1.00000E 00
  2     2.00000E-01     1.00000E 00
  3     4.00000E-01     1.00000E 00
  4     6.00000E-01     1.00000E 00
  5     8.00000E-01    -3.33000E 00
  6     1.00000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    10   15    5
  1     0.0             1.00000E 00
  2     2.00000E-01     1.00000E 00
  3     4.00000E-01     1.00000E 00
  4     6.00000E-01     1.00000E 00
  5     8.00000E-01    -3.33000E 00
  6     1.00000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    10   15    6
  1     0.0             1.00000E 00
  2     2.00000E-01     1.00000E 00
  3     4.00000E-01     1.00000E 00
  4     6.00000E-01     1.00000E 00
  5     8.00000E-01    -3.33000E 00
  6     1.00000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    1
  1     0.0             1.00000E 00
  2     5.00000E-01     1.00000E 00
  3     1.00000E 00     1.00000E 00
  4     1.50000E 00     1.00000E 00
  5     2.00000E 00    -3.33000E 00
  6     2.50000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    2
  1     0.0             1.00000E 00
  2     4.00000E 00     1.00000E 00
  3     8.00000E 00     1.00000E 00
  4     1.20000E 01     1.00000E 00
  5     1.60000E 01    -3.33000E 00
  6     2.00000E 01    -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    3
  1     0.0             1.00000E 00
  2     4.00000E 00     1.00000E 00
  3     8.00000E 00     1.00000E 00
  4     1.20000E 01     1.00000E 00
  5     1.60000E 01    -3.33000E 00
  6     2.00000E 01    -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    4
  1     0.0             1.00000E 00
  2     2.00000E-01     1.00000E 00
  3     4.00000E-01     1.00000E 00
  4     6.00000E-01     1.00000E 00
  5     8.00000E-01    -3.33000E 00
  6     1.00000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    5
  1     0.0             1.00000E 00
  2     2.00000E-01     1.00000E 00
  3     4.00000E-01     1.00000E 00
  4     6.00000E-02     1.00000E 00
  5     8.00000E-01    -3.33000E 00
  6     1.00000E 00    -3.33000E 00
```

Figure 95. (Continued).

```
KR TABLE FOR I,J,L =    16   17    6
   1     0.0              1.00000E 00
   2     2.00000E-01      1.00000E 00
   3     4.00000E-01      1.00000E 00
   4     6.00000E-01      1.00000E 00
   5     8.00000E-01     -3.33000E 00
   6     1.00000E 00     -3.33000E 00

KR TABLE FOR I,J,L =    16   18    1
   1     0.0              1.00000E 00
   2     5.00000E-01      1.00000E 00
   3     1.00000E 00      1.00000E 00
   4     1.50000E 00      1.00000E 00
   5     2.00000E 00     -3.33000E 00
   6     2.50000E 00     -3.33000E 00

KR TABLE FOR I,J,L =    16   18    2
   1     0.0              1.00000E 00
   2     4.00000E 00      1.00000E 00
   3     8.00000E 00      1.00000E 00
   4     1.20000E 01      1.00000E 00
   5     1.60000E 01     -3.33000E 00
   6     2.00000E 01     -3.33000E 00

KR TABLE FOR I,J,L =    16   18    3
   1     0.0              1.00000E 00
   2     4.00000E 00      1.00000E 00
   3     8.00000E 00      1.00000E 00
   4     1.20000E 01      1.00000E 00
   5     1.60000E 01     -3.33000E 00
   6     2.00000E 01     -3.33000E 00

KR TABLE FOR I,J,L =    16   18    4
   1     0.0              1.00000E 00
   2     2.00000E-01      1.00000E 00
   3     4.00000E-01      1.00000E 00
   4     6.00000E-01      1.00000E 00
   5     8.00000E-01     -3.33000E 00
   6     1.00000E 00     -3.33000E 00

KR TABLE FOR I,J,L =    16   18    5
   1     0.0              1.00000E 00
   2     2.00000E-01      1.00000E 00
   3     4.00000E-01      1.00000E 00
   4     6.00000E-01      1.00000E 00
   5     8.00000E-01     -3.33000E 00
   6     1.00000E 00     -3.33000E 00

KR TABLE FOR I,J,L =    16   18    6
   1     0.0              1.00000E 00
   2     2.00000E-01      1.00000E 00
   3     4.00000E-01      1.00000E 00
   4     6.00000E-01      1.00000E 00
   5     8.00000E-01     -3.33000E 00
   6     1.00000E 00     -3.33000E 00

JJ,I,J,VMAX(I,J,1-6)
   1  1  2   1.000000 01   1.000000D 01   1.000000 01   1.000000 01   1.000000 01   1.000000D 01
   2  2  3   1.000000 01   6.000000 00    6.000000 00   1.000000 01   1.000000 01   1.000000D 01
   3  3  4   1.000000 01   1.000000 01    1.000000 01   1.000000 01   1.000000 01   1.000000D 01
   4  4  5   1.000000 01   1.000000 01    1.000000 01   1.000000 01   1.000000 01   1.000000 01
   5  4  7   1.000000 01   1.000000 01    1.000000 01   1.000000 01   1.000000 01   1.000000 01
   6  5  6   1.000000 01   1.000000 01    1.000000 01   1.000000 01   1.000000 01   1.000000D 01
   7  5  7   1.000000 01   1.000000 01    1.000000 01   1.000000 01   1.000000 01   1.000000 01
   8  5 20   1.000000 01   1.000000 01    1.000000 01   1.000000 01   1.000000 01   1.000000D 01
   9  5 21   1.000000 01   1.000000 01    1.000000 01   1.000000 01   1.000000 01   1.000000 01
```

Figure 95. (Continued).

10	5	22	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
11	5	23	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
12	6	9	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
13	6	11	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
14	7	9	1.000000D 00	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
15	8	9	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
16	10	11	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
17	10	14	1.000000D 01	1.000000D 01	1.510000D 01	1.000000D 01	1.000000D 01	1.000000D 01
18	10	15	1.000000D 01	1.000000D 01	1.510000D 01	1.000000D 01	1.000000D 01	1.000000D 01
19	10	22	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
20	10	23	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
21	11	16	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
22	12	16	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
23	12	24	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
24	13	16	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
25	13	25	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
26	16	17	1.000000D 01	1.000000D 01	1.510000D 01	1.000000D 01	1.000000D 01	1.000000D 01
27	16	18	1.000000D 01	1.000000D 01	1.510000D 01	1.000000D 01	1.000000D 01	1.000000D 01
28	16	19	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
29	20	21	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
30	20	22	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
31	21	23	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
32	24	25	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
33	10	26	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
34	16	27	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
35	26	28	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
36	27	29	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
37	26	30	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
38	27	31	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01

PLOT CARDS WHICH ARE NOT ALL BLANK

```
             1         2         3         4         5         6         7         8
    12345678901234567890123456789012345678901234567890123456789012345678901234567890

3         11 1     1                                                            5005
6         11 1     1                                                            5006
8         11 11    1                                                            5008
9         11 11    1         11  11                                             5009
12           1111  1     11                                                     5012
13      1 1       1                     11                                      5013
14      1 1       1                                                             5014
15      1 1       1                                                             5015
25                                      11                                      5025
```

```
INDP =  9
XN-,XP-,YN-,YP-,ZN-,ZP-
   2.200000 01    9.000000 01    4.500000 01    4.500000 01    9.000000D 00    4.500000 01
```

DRI(IJ) INDICATORS

```
             1         2         3         4         5         6         7         8
    123456789012345678901234567890123456789012345678901234567890123456789012345678.0

                                        11                                      7000
```

```
IJ,THEIJ(IJ),PSIIJ(IJ)
   1   -8.375070-01    0.0
   2   -1.491810-01    0.0
   3   -2.965290-01    0.0
   4    0.0            0.0
   5    1.023660 00    0.0
   6    0.0            0.0
   7    2.107750 00    0.0
   8    6.953940-01    1.570800 00
   9    6.953940-01   -1.570800 00
```

Figure 95. (Continued).

10	-3.504650-01	1.570800 00
11	-3.504650-01	-1.570800 00
12	1.570800 00	0.0
13	-1.570800 00	0.0
14	-2.497790-01	0.0
15	-1.762280 00	0.0
16	0.0	0.0
17	-5.187220-01	1.570800 00
18	-5.187220-01	-1.570800 00
19	0.0	1.570800 00
20	0.0	-1.570800 00
21	0.0	0.0
22	0.0	-1.570570 00
23	1.570610 00	0.0
24	0.0	1.570570 00
25	1.570610 00	0.0
26	-5.187220-01	1.570800 00
27	-5.187220-01	-1.570800 00
28	0.0	0.0
29	0.0	-1.570800 00
30	-1.570800 00	0.0
31	-1.570800 00	0.0
32	0.0	-1.570800 00
33	1.570800 00	0.0
34	1.570800 00	0.0
35	1.570800 00	0.0
36	1.570800 00	0.0
37	1.570800 00	0.0
38	1.570800 00	0.0
39	-1.971710-01	0.0

Figure 95. (Continued).

RUN SE-31-100 COMBINED VEL. IMPACT 0100

TIME = 0.10000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 1	-2.93784D 02	-2.31669D 01	-1.17497D 02	-5.51100D-03	2.06048D-02	5.72520D-03
	1.94684D 02	-2.54987D 02	1.45101D 02	-4.02728D-01	-6.04058D-01	4.40062D-01
	1.90161D 02	-2.56916D 02	1.47676D 02	-4.11882D-01	-6.06474D-01	4.36631D-01
	-6.97825D 03	-1.06220D 03	-6.92168D 03	-1.07673D 01	6.80112D 01	1.32182D 01
	-1.80198D 01	-2.37913D 00	-1.73589D 01			
MASS 2	-2.37520D 02	-2.23983D 01	-5.81652D 01	-1.79160D-02	2.47160D-02	6.51187D-03
	2.21105D 02	-2.05848D 02	1.16537D 02	-4.66249D-01	1.41834D 00	4.39689D-01
	2.16812D 02	-2.09434D 02	1.18199D 02	-4.77115D-01	1.41024D 00	4.64893D-01
	-2.44093D 03	2.97346D 03	-1.08726D 04	-8.73206D 01	3.66412D 00	-7.68449D 00
	-5.63957D 00	8.11050D 00	-2.87007D 01			
MASS 3	-7.41646D 01	-2.10066D 01	-3.65481D 01	-2.52574D-02	5.74538D-03	4.10872D-03
	2.36878D 02	-1.48006D 02	-4.07682D 01	-4.70295D-01	1.01537D-01	-3.34840D-03
	2.36499D 02	-1.47935D 02	-4.31559D 01	-6.70266D-01	1.01589D-01	-7.83001D-04
	-3.40502D 03	3.80009D 03	-1.05931D 04	-1.31280D 01	-7.18207D 00	-1.19267D 01
	-8.63296D 00	9.76913D 00	-2.72486D 01			
MASS 4	-4.45360D 01	-2.06634D 01	-2.75897D 01	-2.57944D-02	-3.06830D-04	3.44499D-03
	2.34919D 02	-1.44131D 02	-3.82452D 01	-7.02020D-01	-3.10878D-01	-1.56039D-01
	2.34405D 02	-1.43903D 02	-4.20411D 01	-7.02069D-01	-3.06751D-01	-1.64002D-01
	-3.63675D 03	3.50893D 03	-1.04215D 04	-7.96838D 00	-1.14846D 01	-1.61743D 01
	-9.44935D 00	8.91443D 00	-2.65508D 01			
MASS 5	4.05745D 00	-2.05066D 01	-2.75532D 01	-2.57829D-02	-1.46968D-03	2.71510D-03
	2.34735D 02	-1.53233D 02	-2.18010D 01	-7.01732D-01	-3.67185D-01	-2.13881D-01
	2.34286D 02	-1.53248D 02	-2.61048D 01	-7.02047D-01	-3.61549D-01	-2.23276D-01
	-3.61824D 03	2.72302D 03	-9.78853D 03	-7.96011D 00	-1.38202D 01	-1.45948D 01
	-9.43788D 00	6.87147D 00	-2.48607D 01			
MASS 6	2.60326D 01	-2.04738D 01	-2.74504D 01	-2.57828D-02	-7.08953D-03	1.06500D-03
	2.33171D 02	-1.58346D 02	-1.25964D 01	-7.01831D-01	-4.64550D-01	-2.33733D-01
	2.32907D 02	-1.58175D 02	-1.83317D 01	-7.03488D-01	-4.58370D-01	-2.45625D-01
	-3.51277D 03	2.39101D 03	-9.66416D 03	[illegible] 00	-3.52605D 00	-1.77599D 01
	-9.17932D 00	6.01270D 00	-2.44718D 01			
MASS 7	-1.98772D 01	-2.16348D 01	-6.77327D 01	-2.64626D-02	-1.84709D-03	3.75471D-03
	2.47038D 02	-1.74118D 02	-3.39790D 01	-6.00163D-01	-2.47809D-01	-3.29630D-01
	2.46319D 02	-1.74072D 02	-3.90536D 01	-6.00771D-01	-2.39000D-01	-3.36071D-01
	-1.82684D 03	2.23477D 03	-1.16113D 04	-2.73281D 01	-5.71735D 01	-2.96024D 01
	-4.86013D 00	5.51432D 00	-2.96576D 01			
MASS 8	3.32643D 01	-2.20185D 01	-8.29096D 01	-2.31635D-02	-5.40455D-02	-7.32502D-03
	3.14971D 02	-2.04664D 02	4.28053D 00	-9.63444D-01	-1.92568D 00	-4.05998D-01
	3.16231D 02	-2.02000D 02	-1.75040D 01	-1.85376D-01	-1.91578D 00	-4.49898D-01
	3.53495D 00	1.51621D 03	-9.34823D 03	-2.64830D 01	-7.80195D 01	-1.36726D 01
	-1.39406D-01	3.51474D 00	-2.21330D 01			

Figure 96. Typical Output, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

RUN SE-31-100 COMBINED VEL. IMPACT 0100

TIME = 0.10000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 9	2.631900 01	-2.124670 01	-5.603770 01	-2.777980-02	-1.305530-02	2.154960-04
	2.502520 02	-1.800170 02	-1.232710 01	-6.101590-01	-6.704870-01	-2.682480-01
	2.500310 02	-1.795690 02	-2.058830 01	-8.136610-01	-6.627780-01	-2.867450-01
	-3.079220 03	2.109720 03	-9.760600 03	-1.318430 01	-1.755510 01	-2.178370 01
	-8.075290 00	5.236470 00	-2.447920 01			
MASS 10	3.838520 00	-2.002530 01	-1.179550 01	-2.427930-02	-5.937590-02	-6.419530-03
	2.238440 02	-1.419830 02	-3.304940 01	-5.489590-01	-1.854530 00	-3.819760-01
	2.223940 02	-1.393770 02	-4.972640 01	-5.716260-01	-1.844730 00	-4.262130-01
	-3.495640 03	2.649330 03	-8.041380 03	1.516740 01	8.103670 01	1.102760 01
	-8.972830 00	6.544350 00	-1.956340 01			
MASS 11	2.588350 01	-2.006660 01	-1.100750 01	-2.427840-02	-1.054170-02	1.702580-03
	2.235340 02	-1.470470 02	-1.257960 01	-6.881470-01	-6.745840-01	-1.750500-01
	2.231380 02	-1.470220 02	-1.850720 01	-6.899930-01	-6.701360-01	-1.913650-01
	-3.333560 03	2.656790 03	-9.707520 03	-2.505020 01	2.912140 01	-1.556550 01
	-8.676930 00	6.739170 00	-2.449880 01			
MASS 12	9.527820 01	2.499980 01	-1.400310 01	-2.891720-02	-2.280660-02	-6.181390-04
	2.266400 02	-1.603340 02	-9.271710 00	1.229310 00	-3.258560-01	-9.354570-02
	2.264680 02	-1.597100 02	-1.906570 01	1.727130 00	-3.279580-01	-1.049020-01
	-5.006610 03	1.540520 03	-9.092420 03	-3.282150 01	-3.329300 01	7.507000 01
	-1.299850 01	3.990040 00	-2.387370 01			
MASS 13	9.534950 01	-6.498400 01	-1.258250 01	-4.716330-03	-2.825570-02	4.051550-04
	2.006530 02	-1.610610 02	-4.142760 01	7.657660-01	-8.744670-01	-7.259600-01
	1.993370 02	-1.608220 02	-4.815930 01	7.452560-01	-8.695730-01	-7.315270-01
	-4.778590 03	1.413050 03	-1.270400 04	1.131230 02	-2.257860 01	-3.346760 01
	-1.257610 01	3.375970 00	-3.277330 01			
MASS 14	1.045600-01	4.233390 01	-4.441950 00	-7.468000-03	-1.385490-01	1.404430-01
	3.073910 02	-7.569720 01	-8.247360 01	9.888910 00	-1.753590 00	-2.459680-01
	2.795630 02	-1.170650 02	-1.231320 02	9.854540 00	-1.751730 00	-2.566990-01
	-1.323350 02	-1.144960 03	1.046240 03	1.473700-01	8.290800-01	0.0
	1.381070-01	-7.396370-03	9.903900-01			
MASS 15	4.680220-01	-8.796720 01	-7.974130 00	8.565930-02	-1.243250-01	-1.546580-01
	2.842070 02	-4.055270 02	-1.549410 02	-6.958410 00	-1.707130 00	-1.114420 00
	3.214200 02	-3.723940 02	-1.650590 02	-7.096610 00	-1.795480 00	-9.557120-01
	1.074070 02	1.511310 03	-2.838220 03	5.623730-01	-2.222770 00	0.0
	1.240050-01	8.489430-02	9.886430-01			
MASS 16	9.529940 01	-1.998520 01	-1.281440 01	-1.999330-02	2.629910-03	1.806230-03
	2.203560 02	-1.609680 02	-3.347960 01	-2.106050-01	-1.036510 00	-1.375380-01
	2.201530 02	-1.606760 02	-3.612020 01	-2.102430-01	-1.033550 00	-1.582320-01
	-3.070180 03	1.488960 03	-9.603640 03	8.186020 01	-2.020510 01	-1.090700 01
	-7.922990 00	3.747540 00	-2.420290 01			

Figure 96. (Continued).

RUN SE-31-100 COMBINED VEL. IMPACT 0100

TIME = 0.10000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 17	9.073610 01	4.219210 01	-3.925540 00	-3.424670-01	-5.72654D-02	1.79543D-01
	2.758320 02	-7.079260 01	-7.75198D 01	1.45786D 00	-3.77241D-01	1.558490 00
	2.538950 02	-8.104470 01	-1.26781D 02	1.54706D 00	-8.77838D-01	1.338900 00
	-1.977110 02	-6.654890 02	2.654900 02	-6.73415D-01	-1.18679D 00	-1.480300-16
	5.72341D-02	-3.35262D-01	9.40385D-01			
MASS 18	9.201220 01	-8.412170 01	-4.36356D 00	3.631290-01	-4.761730-02	-1.48686D-01
	2.811690 02	-3.399290 02	-8.345280 01	-6.012290-01	-2.39436D-01	-1.456400 00
	3.240790 02	-3.104820 02	1.208030 01	-6.705520-01	-7.405490-01	-1.274830 00
	4.231330 02	5.419990 02	-8.777110 01	5.409120-01	-4.897850-01	-1.480300-16
	4.759930-02	3.547980-01	9.337310-01			
MASS 19	1.439320 02	-1.989250 01	-1.286090 01	-1.97985D-02	4.429600-05	1.944670-03
	2.194150 02	-1.675610 02	6.817230 00	-6.464570-01	-7.11848D-01	-1.336440-01
	2.190930 02	-1.680860 02	3.668010 00	-6.464510-01	-7.092100-01	-1.47001D-01
	-2.990810 03	9.466110 02	-7.514200 03	1.07226D 01	-6.081680 01	-1.109890 01
	-7.818970 00	2.375070 00	-1.67828D 01			
MASS 20	8.572190 00	2.351700 01	-6.635600 01	-2.83264D-02	-9.907300-02	1.333570-02
	5.090570 02	-1.794130 02	-4.351070 01	-7.665010-01	-6.038080 00	1.028230 00
	4.998310 02	-1.834650 02	-9.664330 01	-6.647970-01	-6.06464D 00	9.51764D-01
	7.077550 03	2.313510 03	-1.174470 04	1.79773D 01	-2.246830 02	-8.672980 00
	2.029030 01	6.926610 00	-2.225770 01			
MASS 21	9.346010 00	-6.632250 01	-6.414730 01	-2.217940-02	-1.398640-01	1.059540-02
	5.663140 02	-1.647780 02	2.891730 01	-1.024550 00	-8.567780 00	1.209550 00
	5.628460 02	-1.896110 02	-5.425510 01	-8.55932D-01	-8.592240 00	1.007430 02
	1.001570 04	7.993010 02	-1.302690 04	-3.895870 01	-2.048300 02	4.190420 01
	2.765000 01	3.419410 00	-3.079920 01			
MASS 22	3.143030 00	2.498460 01	-1.272870 01	-2.844200-02	-9.469050-02	1.677870-02
	2.323640 02	-1.423020 02	-6.048320 01	-8.13968D-01	-4.645470 00	2.334520-01
	2.231950 02	-1.437910 02	-8.607710 01	-7.918950-01	-4.650200 00	1.002040-01
	-2.059860 03	2.566300 03	-9.270970 03	-7.214520 00	-1.101120 02	-2.913230 01
	-4.262120 00	6.561600 00	-2.103420 01			
MASS 23	2.410910 00	-6.517550 01	-1.073640 01	-1.479790-02	-1.316370-01	-4.086180-02
	1.534200 02	-1.453660 02	-1.321850 01	-5.724160-02	-7.242200 00	-2.106830 00
	1.561180 02	-1.384610 02	-3.605720 01	-3.337790-01	-7.210500 00	-2.195540 00
	-2.209510 03	2.382060 03	-1.033520 04	3.73305D 01	-2.395240 02	4.074940 01
	-5.838130 00	5.251970 00	-2.373910 01			
MASS 24	9.651260 01	2.372440 01	-6.797220 01	-2.031270-02	-2.229180-02	3.384820-03
	2.411310 02	-1.684390 02	-6.56236D 00	-2.019890 00	-2.236300-01	1.07448D-04
	2.403090 02	-1.689360 02	-1.735720 01	-2.019890 00	-2.235860-01	-4.634840-03
	-3.384420 03	8.841320 03	-9.845910 03	1.660690 02	-2.975700 01	2.197530 01
	-8.759820 00	2.281140 01	-2.448430 01			

Figure 96. (Continued).

RUN SE-31-100 COMBINED VEL. IMPACT 0100

TIME = 0.10000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 25	9.681900 01	-6.626370 01	-6.654630 01	-3.087490-02	-2.612220-02	3.785710-03
	2.442640 02	-1.697780 02	-4.104110 01	-1.992380-01	-8.160850-01	-9.844010-04
	2.424640 02	-1.691570 02	-5.263720 01	-1.992630-01	-8.156660-01	-2.617610-02
	-2.484000 03	8.522940 03	-1.295300 04	5.036990 01	-6.400890 01	8.198300-01
	-6.335470 00	2.203650 01	-3.295740 01			
MASS 26	4.422960 00	-2.027120 01	-2.137960 01	-2.198670-02	-6.197930-02	1.317860-03
	2.436950 02	-1.470280 02	-1.911640 01	-7.237350-01	-4.116860 00	-3.364610-01
	2.416560 02	-1.465620 02	-1.739320 01	-7.445750-01	-4.108480 00	-4.262430-01
	-3.714180 03	3.269430 03	-9.198680 03	-6.427370 01	1.251380 02	-2.355050 01
	-9.386080 00	8.130830 00	-2.097390 01			
MASS 27	9.527400 01	-2.019180 01	-2.264940 01	-2.013100-02	6.714790-03	3.903830-03
	2.298580 02	-1.640320 02	-3.307460 01	-5.582300-01	-1.112520 00	1.514070-04
	2.294330 02	-1.642600 02	-3.484830 01	-5.582310-01	-1.112300 00	-2.224330-02
	-2.432110 03	2.245180 03	-1.079660 04	1.832070 01	-1.050300 02	-8.334890 00
	-6.209850 00	5.752920 00	-2.707220 01			
MASS 28	4.902730 00	-2.045210 01	-2.954740 01	-2.034260-02	-5.886640-02	4.642210-03
	2.760930 02	-1.510370 02	4.106620 01	-5.880990-01	-5.395370 00	-1.372740-01
	2.773280 02	-1.527900 02	2.168580 01	-5.961750-01	-5.391460 00	-2.467560-01
	-4.174880 03	2.983440 03	-1.055930 04	-1.301050 02	5.794400 01	-3.004610 01
	-1.121640 01	7.585330 00	-2.324620 01			
MASS 29	9.521080 01	-2.036510 01	-3.119200 01	-1.935730-02	9.122070-03	4.526060-03
	2.386530 02	-1.672510 02	6.472440 01	-6.388680-01	-1.079190 00	5.306500-02
	2.372940 02	-1.695930 02	6.362100 01	-6.393520-01	-1.080020 00	3.216390-02
	-1.359100 03	2.299520 03	-9.408310 03	-3.057440 01	-1.344620 02	-4.610210 00
	-3.684870 00	6.082450 00	-2.342900 01			
MASS 30	4.873610 00	-2.043920 01	-2.866850 01	-2.015460-02	-5.945500-02	5.014220-03
	2.719780 02	-1.501370 02	6.468630 01	-6.070120-01	-5.638580 00	-1.140920-01
	2.745670 02	-1.524440 02	4.539300 01	-6.137920-01	-5.635140 00	-2.275030-01
	-4.221650 03	3.122630 03	-9.383910 03	-1.340270 02	5.747200 01	-3.075680 01
	-1.168940 01	8.000050 00	-2.005960 01			
MASS 31	9.521560 01	-2.035880 01	-3.081090 01	-1.906960-02	9.176380-03	4.632700-03
	2.387210 02	-1.668240 02	7.636220 01	-6.607170-01	-1.100970 00	5.700310-02
	2.372350 02	-1.693950 02	7.532600 01	-6.612400-01	-1.101850 00	3.599660-02
	-1.395150 03	2.312020 03	-7.052960 03	-4.811210 01	-1.347730 02	-6.716970 00
	-3.813600 00	6.140850 00	-1.730450 01			
MASS 32	1.178450 02	-2.213580 01	-6.128670 01	-2.197020-02	-5.296760-02	-5.291830-03
	2.737740 02	-2.177610 02	1.672420 02	-9.781160-01	-2.037890 00	-3.372820-01
	2.833960 02	-2.196060 02	1.476630 02	-9.959730-01	-2.030000 00	-3.814970-01
	-5.228550 02	2.018220 02	-5.893110 03	-3.576140 01	2.891950 01	-2.578610 01
	-2.348160 00	6.237730-01	-1.321010 01			

IG(IJ),JG(IJ),SUMDF(1,IJ),SUMDF(2,IJ),SUMDF(3,IJ),'SUMDF(4,IJ),SUMDF(5,IJ),SUMDF(6,IJ)

1	2	-3.508070 03	-4.867180 02	2.902240 02	0.0	1.658580 04	2.919290 04
2	3	-3.663970 03	4.428450 01	-3.601350 03	-1.877770 04	-6.997490 05	-3.526330 04
3	4	-5.381350 03	6.952490 02	-5.735750 03	-2.697240 04	-8.784010 05	-7.184110 04
4	5	-1.321090 04	6.246730 03	-2.792160 04	8.899380 04	-1.695270 06	-2.770870 05
4	7	-6.711760 03	-1.169140 03	1.275840 04	0.0	2.687940 05	1.846660 04

Figure 96. (Continued).

5	6	-1.122360 04	-1.488650 04	4.659290 04	-6.408060 04	-7.312060 05	4.354610 04
5	7	-6.335520 03	-2.028840 02	-9.782660 03	0.0	-2.388770 05	-1.813680 04
5	20	1.112600 04	0.0	-9.267770 02	0.0	6.358850 03	0.0
5	21	6.835870 03	0.0	-6.469450 03	0.0	-1.405360 05	0.0
5	22	-1.187400 04	0.0	-2.658140 04	0.0	-7.241340 05	0.0
5	23	-3.379850 04	0.0	-3.470700 04	0.0	-8.435860 05	0.0
6	9	-3.325750 04	-2.810000 03	-6.682090 02	2.578300 04	-1.431080 05	-1.381070 04
6	11	-6.929000 03	-1.786060 04	1.104960 04	4.553700 04	-1.768190 05	2.966050 03
7	9	0.0	0.0	0.0	-4.928820 03	0.0	0.0
8	9	-3.023290 04	2.964540 03	4.888310 03	2.082070 04	1.231230 05	-1.793510 04
10	11	2.872950 04	5.418070 03	2.864780 03	7.769940 02	3.855230 05	1.222390 05
10	14	1.536540 03	2.838690 03	-2.213690 03	3.654780 03	1.466110 05	7.481030 03
10	15	-3.190440 03	-2.561170 03	-6.393380 02	8.024240 03	1.916040 05	4.459730 03
10	22	1.383050 03	3.151910 03	3.263720 04	0.0	7.853880 05	1.280240 04
10	23	1.532740 04	-5.977430 03	2.174440 04	0.0	6.245060 05	-9.541440 02
11	16	2.156990 03	1.325020 04	-1.197000 04	3.220260 03	-3.847760 05	-1.683020 05
12	16	7.478390 02	-3.603310 02	1.897490 03	-2.696270 04	7.508100 04	7.409350 04
12	24	-3.764680 02	2.815720 02	4.243070 01	-1.192090 03	5.439040 03	3.822210 03
13	16	-1.154660 03	8.458610 02	7.636390 03	3.293080 04	2.238240 05	2.089470 04
13	25	-1.311980 03	-1.450160 03	-7.537790 02	-1.019090 03	1.675750 04	7.531660 03
16	17	1.879440 03	1.900590 03	-5.781720 02	-6.151950 03	9.727850 04	-8.951820 03
16	18	-2.147740 03	-1.606720 03	-5.624490 02	5.990040 03	9.786600 04	9.517850 03
16	19	2.564150 03	7.243780 03	1.710040 03	1.279850 03	-5.218640 03	-4.239170 03
20	21	-5.814620 03	-8.160610 01	-7.533790 02	0.0	3.028160 04	-3.621860 03
20	22	-8.766020 03	1.027010 03	-2.646910 03	0.0	-5.796670 04	-3.115780 04
21	23	-9.764240 03	3.278190 03	-4.453820 03	0.0	-9.136250 04	-1.003570 05
24	25	-9.113660 02	7.096900 01	-2.671580 02	2.500860 02	-1.418970 04	-2.257000 03
10	26	-3.950490 03	-1.181300 03	1.310950 03	-7.578920 03	-2.599900 04	2.921590 04
16	27	-4.883720 03	-9.800980 02	4.054110 02	-2.178620 03	4.041480 04	-4.620680 02
26	28	-2.232060 03	-3.423850 02	-2.427600 03	-3.364940 03	2.772880 04	1.874530 04
27	29	-1.788690 03	-1.819080 02	-4.109400 02	-6.682070 02	2.329570 04	7.798610 03
26	30	-1.961590 03	-5.709920 02	-1.167240 03	-3.719300 03	2.309440 04	2.110870 04
27	31	-1.443570 03	-3.492940 02	-1.704960 02	-7.745710 02	2.405530 04	1.080740 04
8	32	9.945050 02	1.609790 02	-1.785610 02	1.686810 03	-2.053020 03	3.644190 03

IG(IJ),JG(IJ),VEE2(1,IJ),VEE2(2,IJ),VEE2(3,IJ),VEE2(4,IJ),VEE2(5,IJ),VEE2(6,IJ)

1	2	-2.657430-02	1.160180-01	-2.718120-02	-7.802220-03	3.877940-03	9.661560-03
2	3	-5.979560-02	-1.316530-01	1.171460 00	-7.620810-03	-1.892350-02	-1.677230-03
3	4	-1.667080-02	-9.176360-03	8.990920-02	-7.391730-04	-6.033500-03	-6.293870-04
4	5	-6.287920-03	-1.110700-02	2.136940-02	1.086220-06	-1.143640-03	-7.596270-04
4	7	-1.256550-01	-2.080610-02	1.503340-01	-5.814190-04	-1.545100-03	-4.398270-04
5	6	-2.469430-02	-2.868610-02	6.975280-02	-7.180710-06	-5.575440-03	-1.794430-03
5	7	-1.765680-01	-2.794580-02	-7.790400-02	-1.349350-04	-4.096090-04	-1.108730-03
5	20	6.953730-02	-4.577220 00	-8.794910-02	-8.024330-02	2.211160-03	-5.655780-02
5	21	4.272420-02	5.110360 00	-2.521600-01	1.036350-01	3.859310-03	9.206760-02
5	22	-6.761940-02	3.691200-01	-4.619740-01	-8.393250-02	1.858170-03	4.292400-02
5	23	-1.924740-01	-1.743100 00	-7.683210-01	1.054590-01	8.226210-03	-5.778540-02
6	9	-1.094000-02	-3.590960-02	8.285270-02	1.007150-03	-5.940640-03	-2.005150-03
6	11	-1.424840-03	-1.665130-02	3.174180-02	5.508280-04	-3.467370-03	-1.510620-03
7	9	1.608160-01	-9.259530-02	-1.738530-01	-2.250600-03	-1.109630-02	-3.392970-03
8	9	-5.940810-01	9.050850-02	2.059550-01	9.229030-03	4.078800-02	2.703510-03
10	11	5.266630-02	1.128720-01	-5.189210-01	3.281220-04	4.862640-02	9.251010-03
10	14	3.208640-03	4.546780 00	-1.510060 01	6.790780-05	3.693720-01	1.419700-01
10	15	-6.653680-03	-3.595580 00	-1.510380 01	1.431340-04	3.898030-01	-1.074740-01
10	22	1.555910-02	6.391780-01	1.960820-01	-3.591540-02	2.299440-03	2.215460-02
10	23	1.724320-01	-1.073290 00	2.816420-02	7.152560-02	6.086790-03	-3.584190-02
11	16	1.269940-02	2.486820-02	-2.538710 00	4.288540-03	1.316460-02	4.696990-04
12	16	4.206070-04	6.612700-02	-1.138620-01	-2.526960-02	9.034290-03	3.065390-03
12	24	-2.541990-03	2.867590-01	-5.897680-03	-3.998970-03	2.397100-04	8.693230-03
13	16	-6.495390-04	4.834950-02	7.127420-02	3.086290-02	1.324380-02	1.854500-03
13	25	-8.858730-03	-9.177080-01	-6.617010-02	-3.418630-03	2.072080-03	-2.406270-02
16	17	7.840820-03	4.550260 00	-1.510230 01	-2.091440-04	3.860080-01	1.308440-01
16	18	-8.960120-03	-3.680620 00	-1.510010 01	2.029000-04	3.866610-01	-1.038580-01
16	19	1.246550-02	3.188340-03	8.153920-02	1.193890-03	-2.588080-03	9.777930-05
20	21	-1.308120-01	-2.037390-01	-3.055910-01	4.070020-02	5.775580-03	-3.879860-03
20	22	-1.183750-01	8.476900-03	-3.197450-01	3.548620-03	4.279690-03	-1.851260-04
21	23	-1.318240-01	2.574080-02	-5.909600-01	-5.082220-02	9.162470-03	-6.396930-04

Figure 96. (Continued).

24	25	-1.025160-03	3.358790-02	-4.025800-01	3.818110-03	-1.055270-02	3.499490-04
10	26	-3.950490-01	-8.981210-03	1.566810-02	-7.578920-03	-2.758590-03	2.831780-03
16	27	-1.627910-01	-9.946660-03	1.275840-05	-2.178620-03	4.041350-03	-1.456730-04
26	28	-1.816160 00	-1.564970-03	-2.732210-02	-3.364940-03	3.046100-03	1.858880-03
27	29	-1.455400 00	-1.049720-03	-6.504010-03	-6.682070-04	2.394610-03	7.693640-04
26	30	-2.495640 00	-3.635400-03	-1.412300-02	-3.719300-03	2.450670-03	2.074520-03
27	31	-1.836600 00	-2.436560-03	-4.152020-03	-7.745710-04	2.447050-03	1.096380-03
8	32	9.945050-03	1.077770-01	-7.365710-02	1.686810-03	1.030740-03	1.753090-03

I,SC(I,1),SC(I,2),SC(I,5)

10	0.0	0.0	5.180160 00
11	0.0	0.0	5.988650 00
12	0.0	0.0	2.987370 00
13	0.0	0.0	4.412220 00
14	0.0	0.0	1.037320-03
15	0.0	0.0	1.674310-03
16	0.0	0.0	4.182980 00
17	0.0	0.0	1.653420-04
18	0.0	0.0	1.043750-03
22	0.0	0.0	4.208850 00
23	0.0	0.0	6.168710 00

MASS	DR*
30	1.634660 01
31	1.202970 01

Figure 96. (Continued).

RUPTURE SUMMARY

I	J	TIME
10	15	0.05676
10	14	0.06142
16	18	0.06284
16	17	0.06510

Figure 96. (Continued).

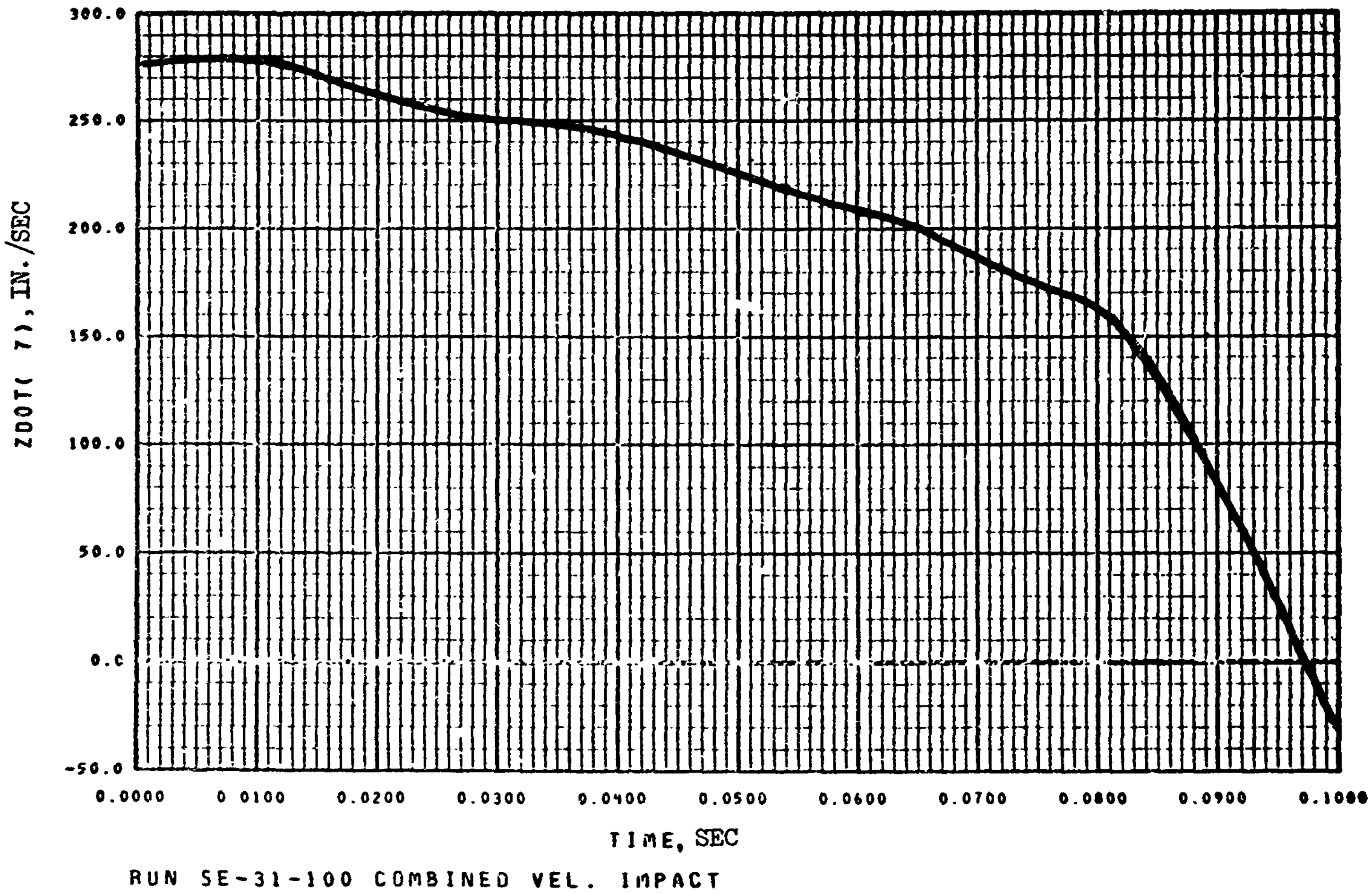


Figure 97. Engine Mass Vertical Velocity, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

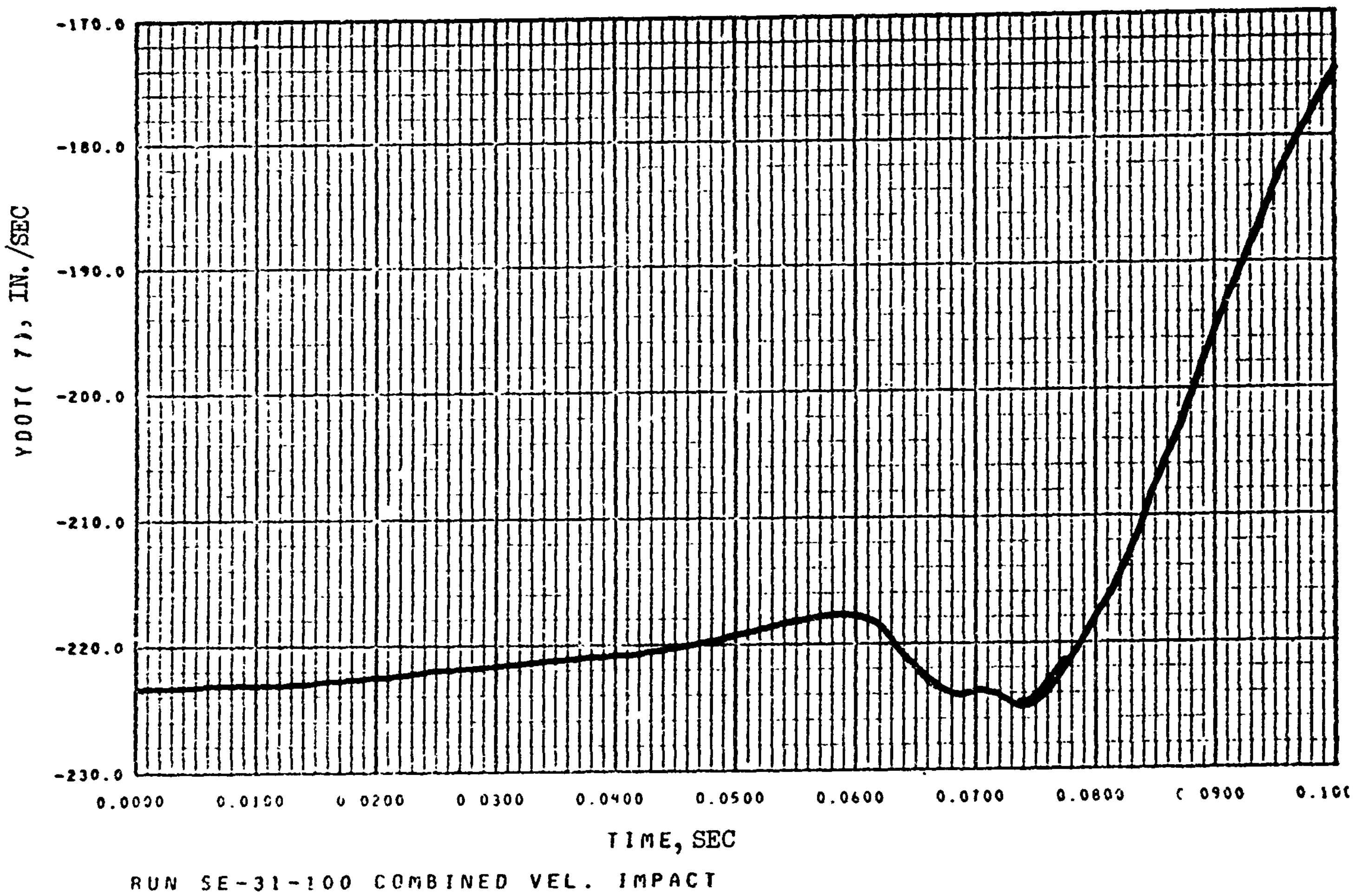
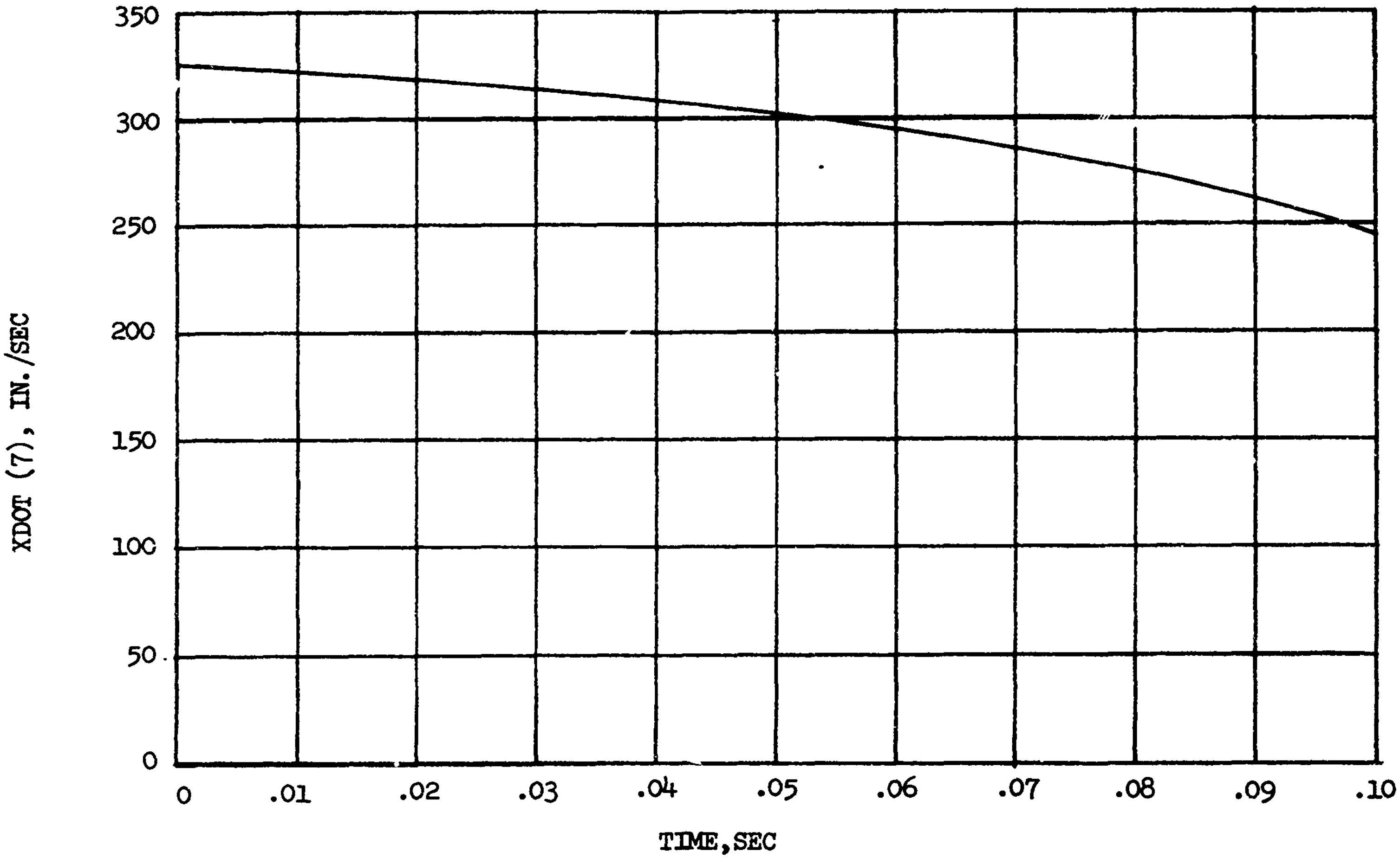


Figure 98. Engine Mass Lateral Velocity, Combined Vertical, Lateral and Longitudinal Impact Sample Case.



RUN SE-31-100 COMBINED VELOCITY IMPACT

Figure 99. Engine Mass Longitudinal Velocity, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

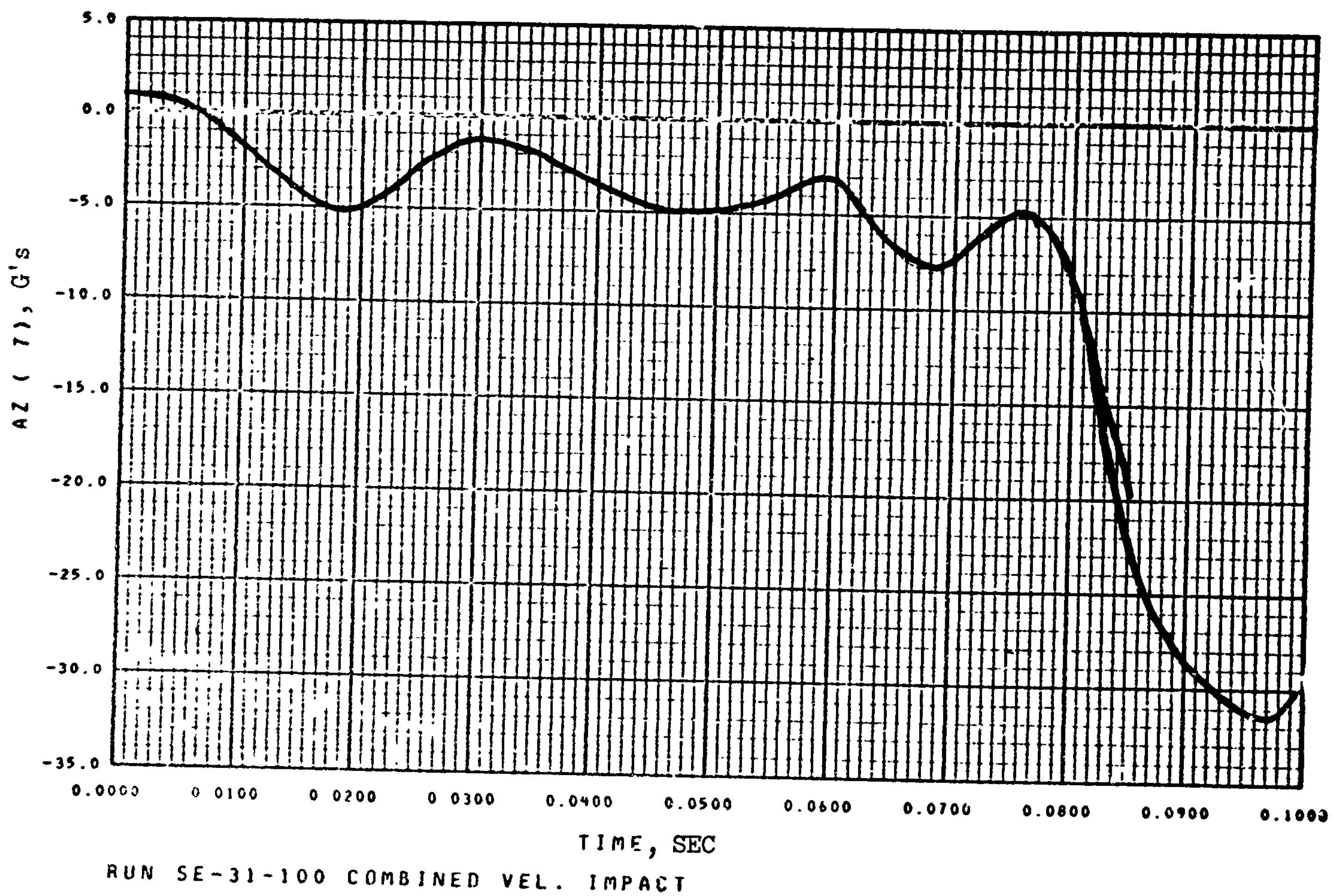


Figure 100. Engine Mass Vertical Acceleration, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

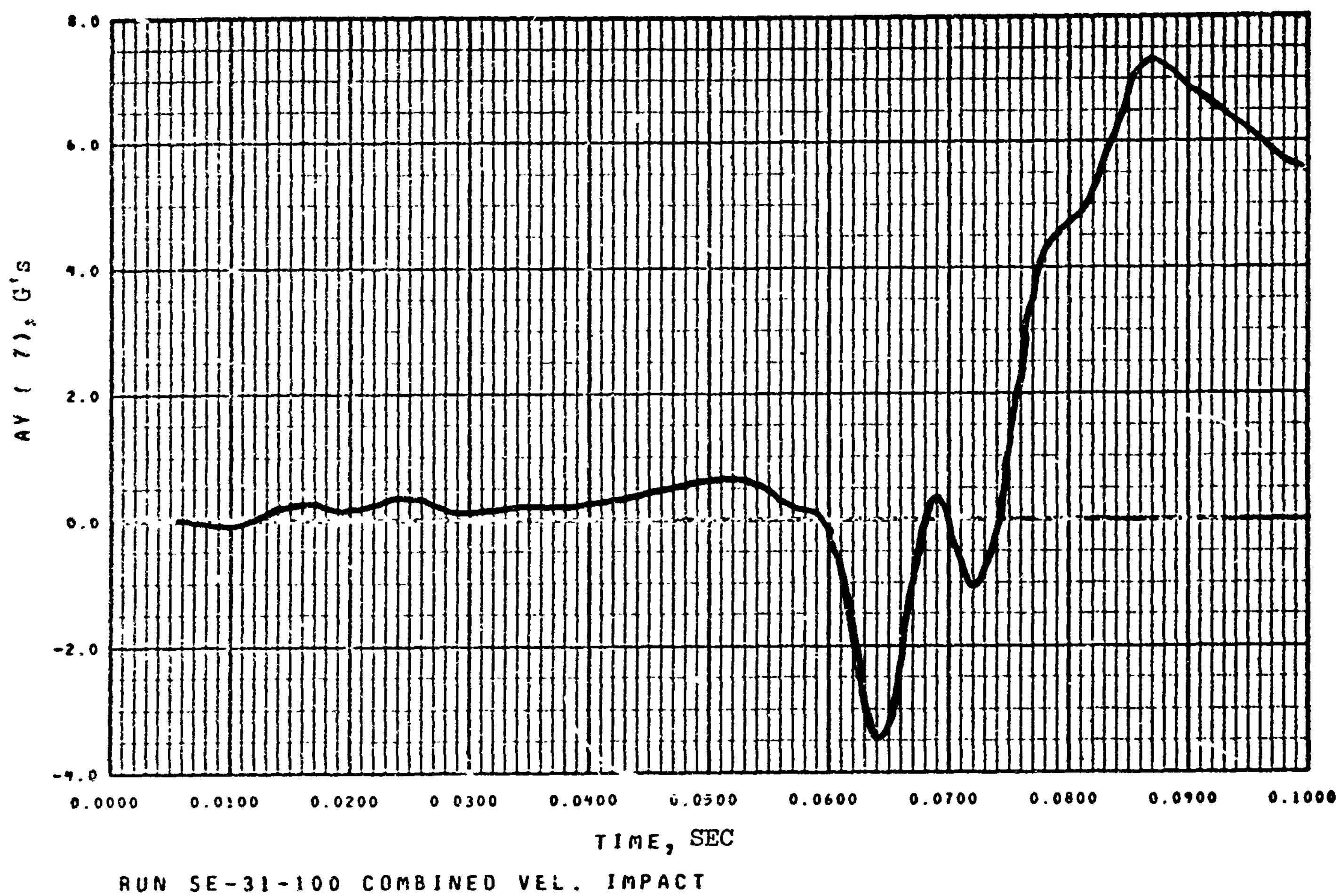


Figure 101. Engine Mass Lateral Acceleration, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

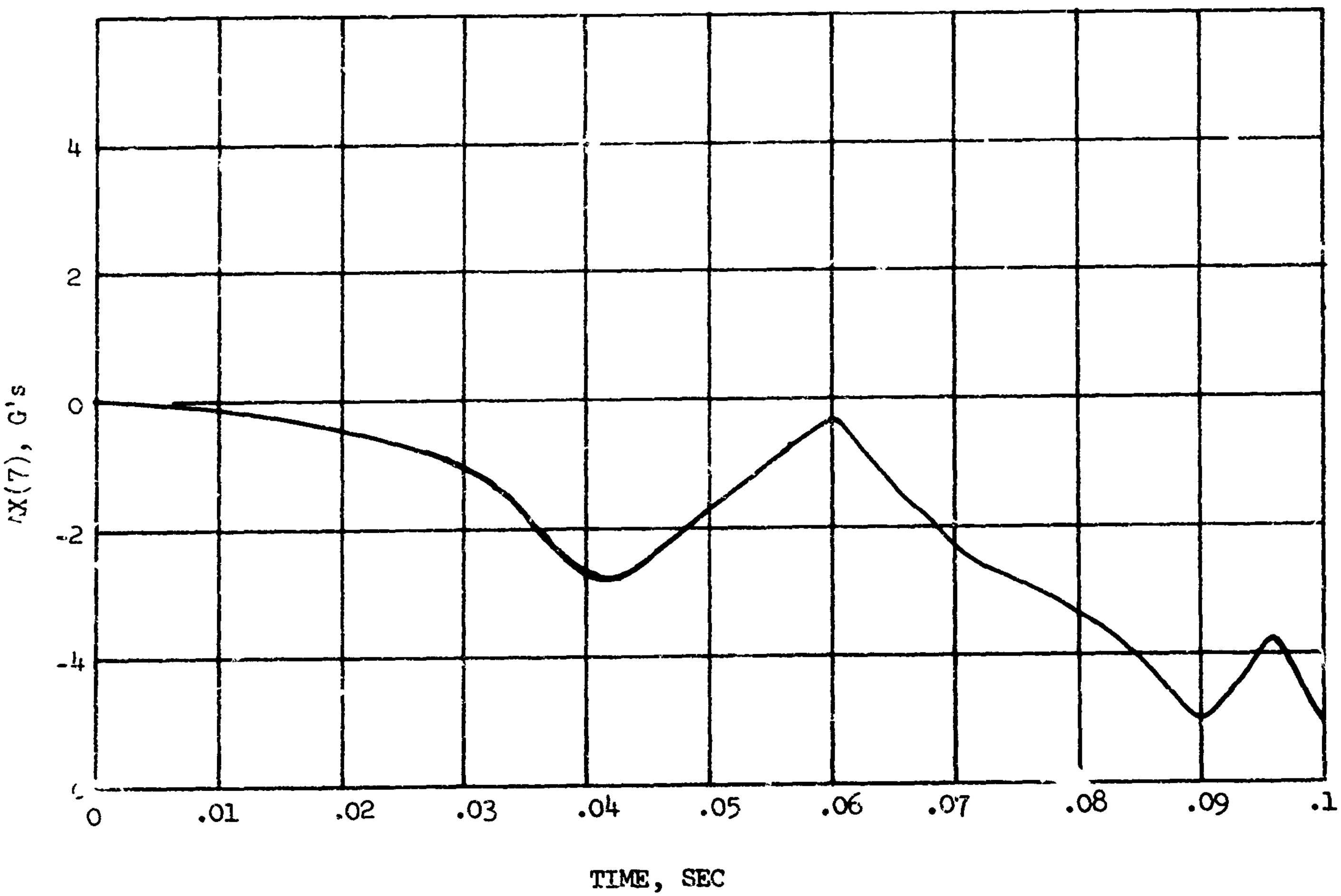


Figure 102. Engine Mass Longitudinal Acceleration, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

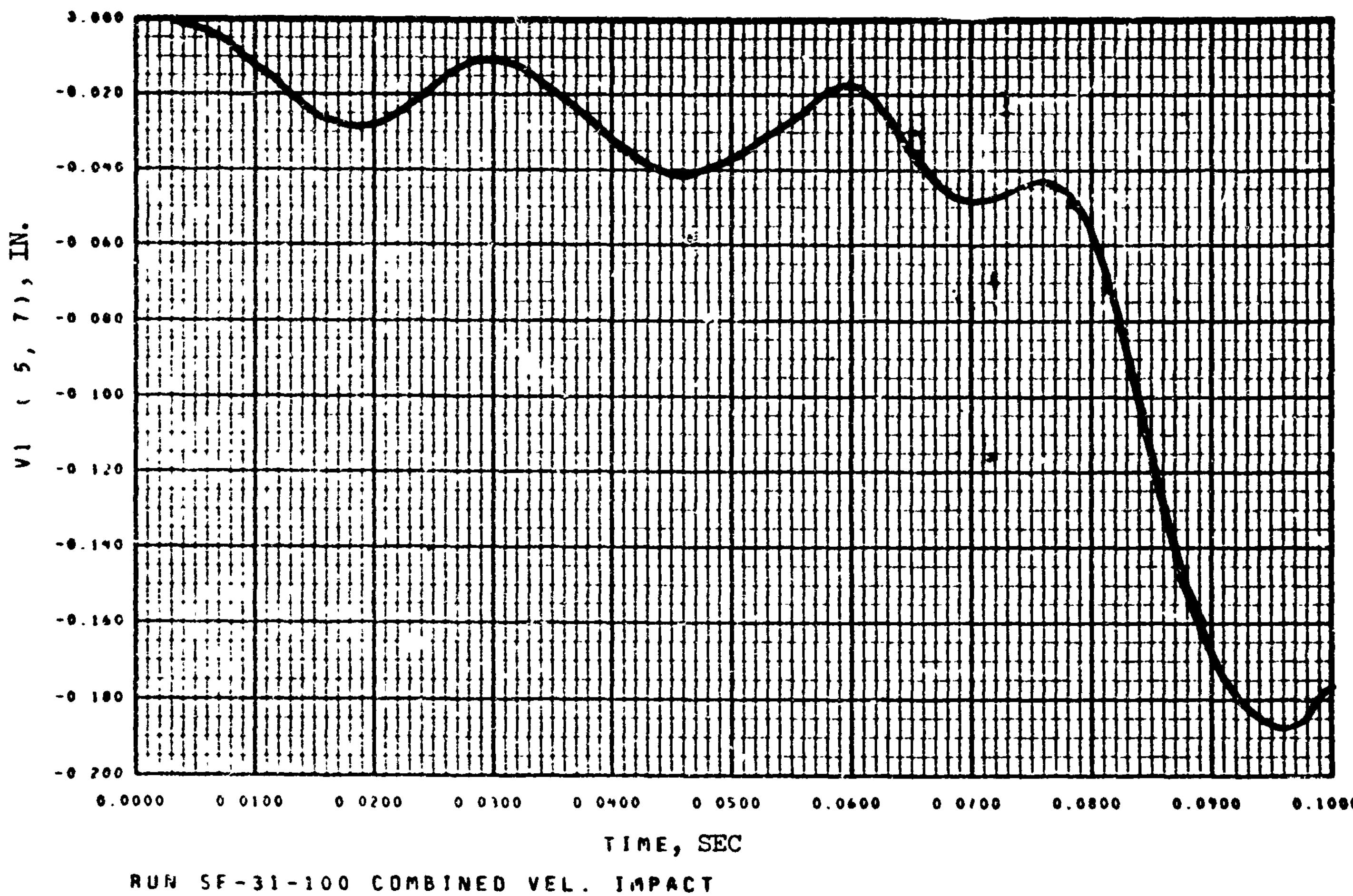


Figure 103. Engine Mount Vertical Deflection, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

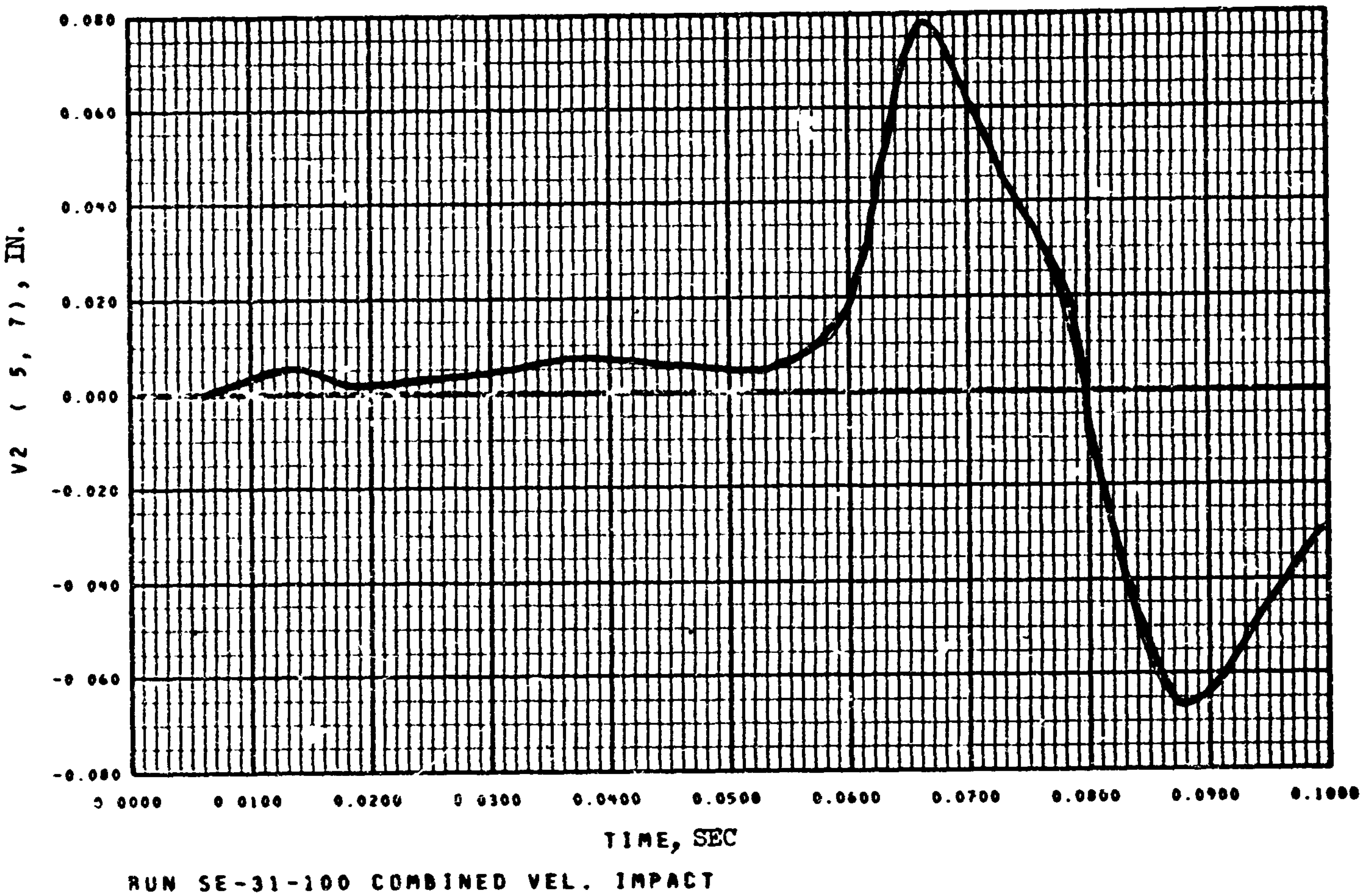


Figure 104. Engine Mount Lateral Deflection, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

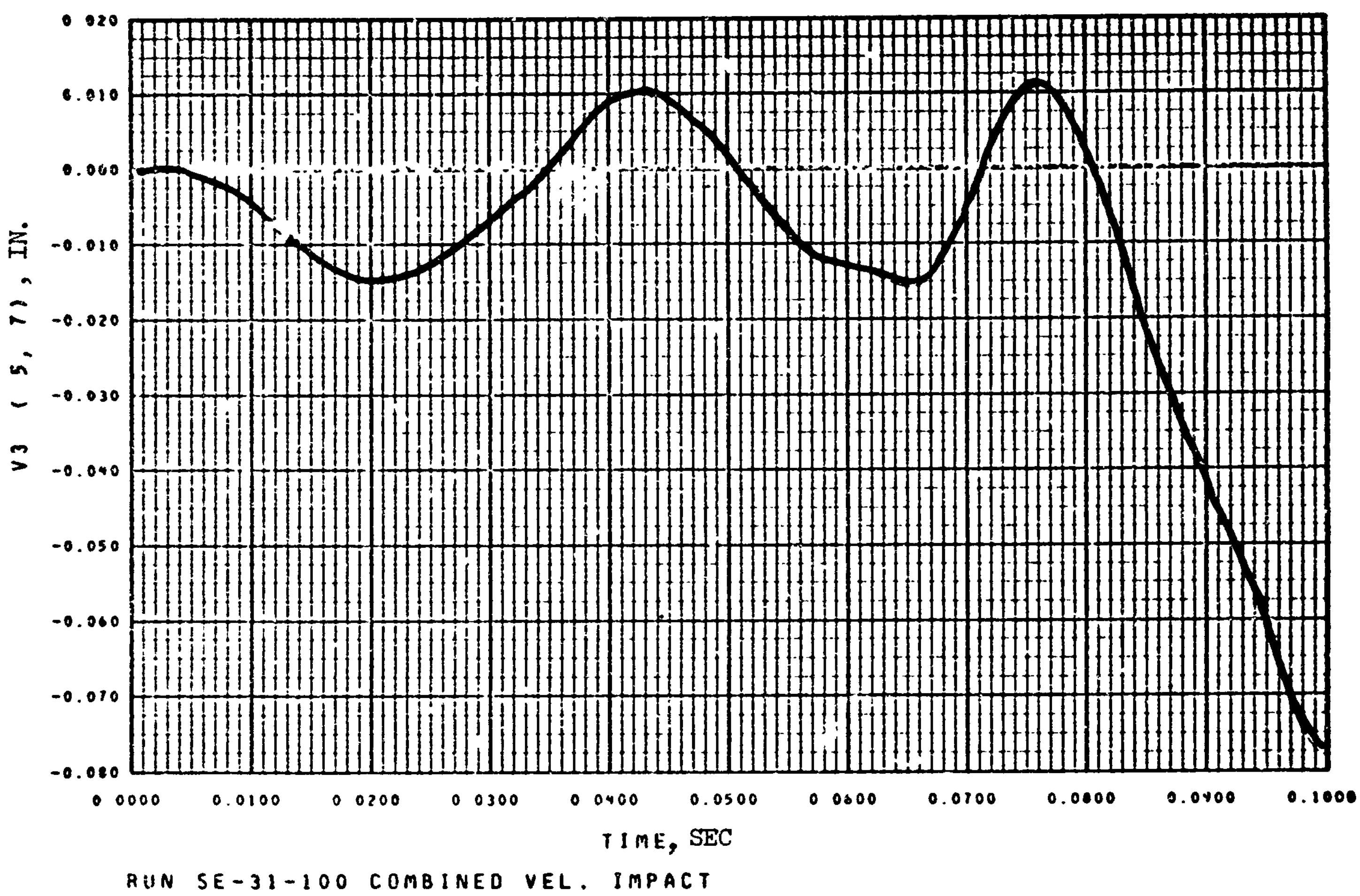


Figure 105. Engine Mount Longitudinal Deflection, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

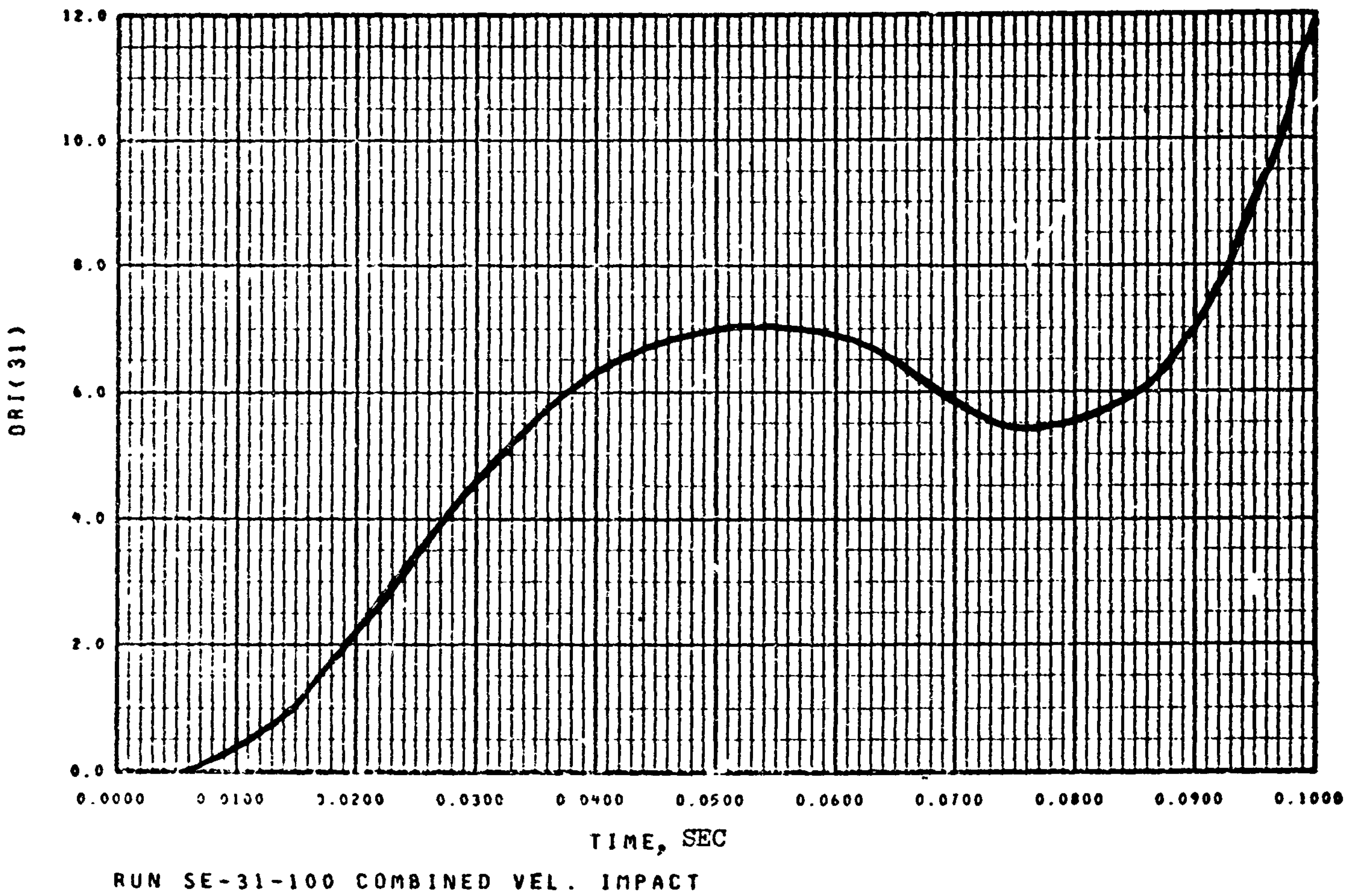


Figure 106. Forward DRI, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

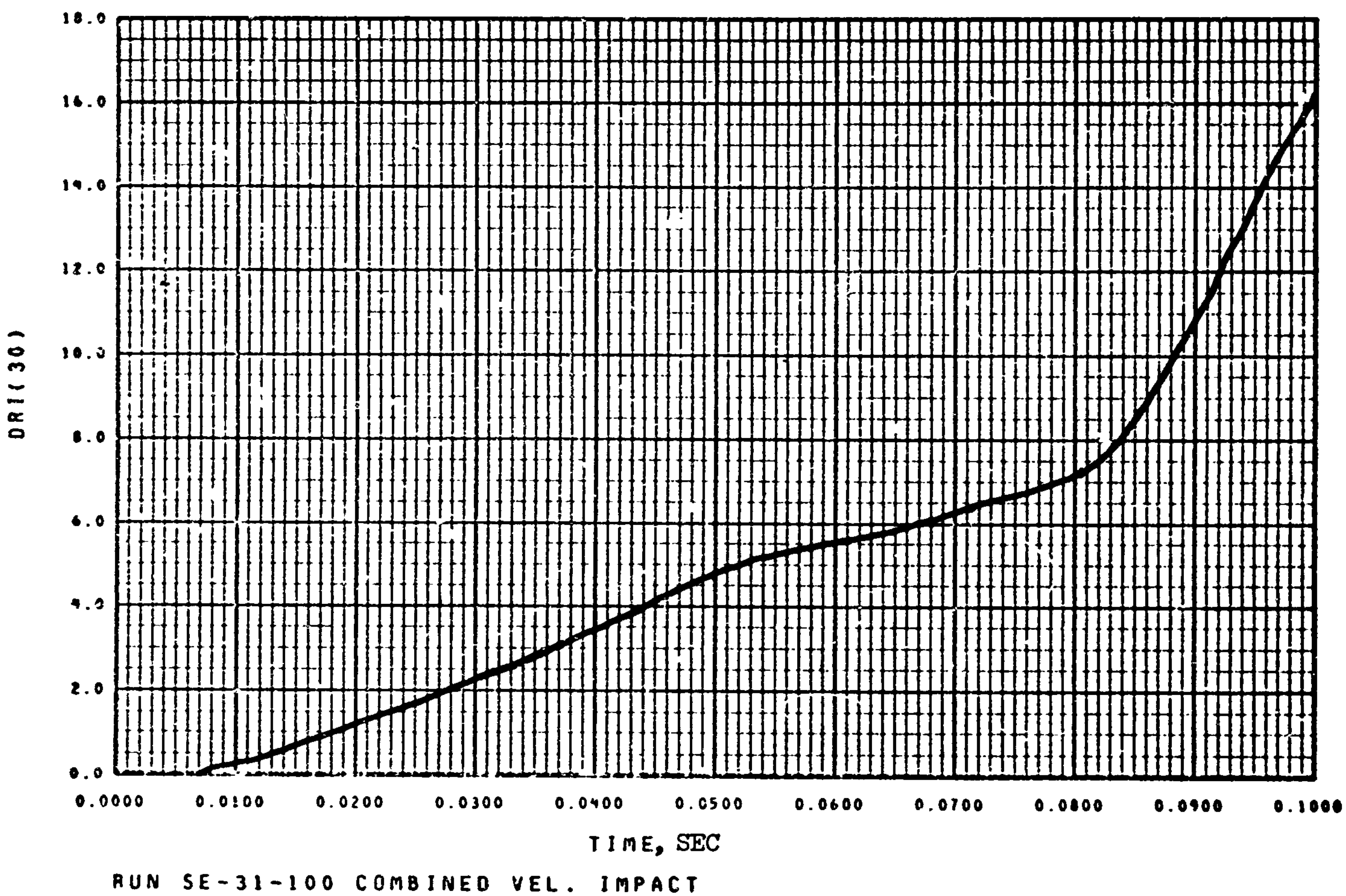


Figure 107. Aft DRI, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

```
LEVEL 20.1 (MAY 71)                         OS/360  FORTRAN H                              DATE  73.298/10.02.22

              COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                                 SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
 ISN 0002          IMPLICIT REAL*8 (A-H,O-Z)                                             CRS00000
 ISN 0003          REAL*4 PLOT,ZAK,TMPLOT                                                CRS00010
 ISN 0004          INTEGER*2      IDPLOT,N,N3,IJPF,ISP,         NN,IBS                   CRS00020
 ISN 0005          DIMENSION DPHI(60),DTHETA(60),DPSI(60),                N3(60,6),      CRS00030
                  1 VEE2(6,60),FM3(6,6,60),FMBAR3(6,6,80)                                CRS00040
 ISN 0006          COMMON/MAINCF/IMAX,IPRINT,ITPLOT,IBS(60,3)                            CRS00050
 ISN 0007          COMMON                  XX(60),XY(60),XZ(60),XL(60),XM(60),           CRS00060
                  1 XN(60),DPX(60),DPY(60),DPZ(60),DPL(60),DPM(60),DPN(60),              CRS00070
                  2 PIN(60),QIN(60),RIN(60),XI1(60),XI2(60),XI3(60),XI4(60),XI5(60),     CRS00080
                  3 XI6(60),XXK(80),XYK(80),XZK(80),XLK(80),XMK(80),XNK(80),AXJ(80),     CRS00090
                  4 XYJ(80),XZJ(80),XLJ(80),XMJ(80),XNJ(80),                             CRS00100
                  5         DELT(60),PULD(60),QOLD(60),ROLD(60),UOLD(60),VOLD(60),       CRS00110
                  6 WOLD(60),XOLD(60),YOLD(60),ZOLD(60),PINU(60),QINU(60),RINU(60),      CRS00120
                  7 DXIJ(80),DYIJ(80),DZIJ(80),PHIOLD(60),THEOLD(60),PSIOLD(60),         CRS00130
                  8 IPEN(60),IRUPT(60),DTHALF,                                           CRS00140
                  9 IJKK,KPEN,KRUPT,IPEN(60),IRUPT(80),JPUPT(80)                         CRS00150
 ISN 0008          COMMON/COMALL/ C(6,60),P(60),Q(60),R(60),U(60),V(60),W(60),X(60),     CRS00160
                  1 Y(60),Z(60),AI(9),AJ(9),FM(2880),SC(60,3),XC(6),XK(2880),XI(60),     CRS00170
                  2 YI(60),ZI(60),XYI(60),XZI(60),YZI(60),AIJ(9),BIJ(540),DIJ(720),      CRS00180
                  3 DRI(60),DAI(540),VEE(480),WGT(60),PHI(60),THETA(60),PSI(60),         CRS00190
                  4 PDOT(60),QDOT(60),RDOT(60),UDOT(60),VDOT(60),WDOT(60),XDOT(60),      CRS00200
                  5 YDOT(60),ZDOT(60),PHIDOT(60),THEDOT(60),PSIDOT(60),TIME,DELTAT,      CRS00210
                  6 XACC(60),YACC(60),ZACC(60),AITAJ(9),AIDOT(9),FMBAR(2880),            CRS00220
                  7 PHIIJ(80),THEIJ(80),PSIIJ(80),SUMDF(6,60),TITLE(10),XLBAR(60,3),     CRS00230
                  8 FSPBAR(60,3),VEEDOT(3,3),DX(60),DY(60),DZ(60),DPIN(60),DRIN(60),     CRS00240
                  9 DEIN(60),SEIJ(80),DEIJ(80),CEIK(60,3),
                  9ZAK(200),PLOT(30000),TMPLOT(500),                                     CRS00250
                  ANM,IGS,  IDT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(150),IG(80),JG(80),        CRS00260
                  0 N(480),NN(60,3),ISP(60,3),IJPR(80),IDPLOT(150)                       CRS00270
 ISN 0009          EQUIVALENCE (N(1),N3(1)),(VEE(1),VEE2(1)),(FM(1),FM3(1)),             CRS00290
                  1 (FMBAR(1),FMBAR3(1))                                                 CRS00300
 ISN 0010          IPLSW = 0                                                             CRS00310
 ISN 0011        1 CALL INPUT                                                            CRS00320
 ISN 0012          IF(NM) 1000,1000,2                                                    CRS00330
 ISN 0013        2 DT2 = 2.0*DELTAT                                                      CRS00340
 ISN 0014          DTHALF = .5*DELTAT                                                    CRS00350
 ISN 0015          KRUPT = 0                                                             CRS00360
 ISN 0016          JPLOT = 0                                                             CRS00370
 ISN 0017          KPEN=0                                                                CRS00380
              C (26)                                                                     CRS00390
 ISN 0018          DO 130 I = 1,NM                                                       CRS00400
```

Figure 108. Program Listing.

```
ISN 0019          XI1(I) = YI(I)*ZI(I)-YZI(I)*YZI(I)                        CRS00410
ISN 0020          XI2(I) = XYI(I)*ZI(I)+XZI(I)*YZI(I)                       CRS00420
ISN 0021          XI3(I) = XYI(I)*YZI(I)+YI(I)*XZI(I)                       CRS00430
ISN 0022          XI4(I) = XI(I)*YZI(I)+XZI(I)*XYI(I)                       CRS00440
ISN 0023          XI5(I) = XI(I)*ZI(I)-XZI(I)*XZI(I)                        CRS00450
ISN 0024          XI6(I) = XI(I)*YI(I)-XYI(I)*XYI(I)                        CRS00460
ISN 0025      130 DELI(I) = 1.0/(XI(I)*XI1(I)-XYI(I)*XI2(I)-XZI(I)*XI3(I))  CRS00470
            C ZERO ARRAYS                                                   CRS00480
ISN 0026          TIME = 0.0                                                CRS00490
ISN 0027          NM9 = 9*NM                                                CRS00500
ISN 0028          DO 140 I = 1,NM9                                          CRS00510
ISN 0029      140 BIJ(I) = 0.0                                              CRS00520
ISN 0030          DO 150 I = 1,NM                                           CRS00530
ISN 0031          DX(I) = 0.0                                               CRS00540
ISN 0032          DY(I) = 0.0                                               CRS00550
ISN 0033          DZ(I) = 0.0                                               CRS00560
ISN 0034          DPHI(I) = 0.0                                             CRS00570
ISN 0035          DTHETA(I) = 0.0                                           CRS00580
ISN 0036          DPSI(I) = 0.0                                             CRS00590
ISN 0037          XX(I) = 0.0                                               CRS00600
ISN 0038          XY(I) = 0.0                                               CRS00610
ISN 0039          XZ(I) = 0.0                                               CRS00620
ISN 0040          XL(I) = 0.0                                               CRS00630
ISN 0041          XM(I) = 0.0                                               CRS00640
ISN 0042          XN(I) = 0.0                                               CRS00650
ISN 0043          DPX(I) = 0.0                                              CRS00660
ISN 0044          DPY(I) = 0.0                                              CRS00670
ISN 0045          DPZ(I) = 0.0                                              CRS00680
ISN 0046          DPL(I) = 0.0                                              CRS00690
ISN 0047          DPM(I) = 0.0                                              CRS00700
ISN 0048          DPN(I) = 0.0                                              CRS00710
ISN 0049          DPTH(I) = 0.0                                             CRS00720
ISN 0050          DGTH(I) = 0.0                                             CRS00730
ISN 0051          DRIN(I) = 0.0                                             CRS00740
ISN 0052          XACC(I)=0.0                                               CRS00750
ISN 0053          YACC(I)=0.0                                               CRS00760
ISN 0054          ZACC(I)=0.0                                               CRS00770
ISN 0055          DO 150 K = 1,3                                            CRS00780
ISN 0056          IBS(I,K) = 0                                              CRS00790
ISN 0057          NN(I,K) = 0                                               CRS00800
ISN 0058          SC(I,K) = 0.0                                             CRS00810
ISN 0059          CEIK(I,K) = 0.0
ISN 0060      150 FSPBAR(I,K) = 0.0                                         CRS00820
ISN 0061          DO 160 IJ = 1,IGS                                         CRS00830
ISN 0062          XXK(IJ) = 0.0                                             CRS00840
ISN 0063          XXJ(IJ) = 0.0                                             CRS00850
ISN 0064          XYK(IJ) = 0.0                                             CRS00860
ISN 0065          XYJ(IJ) = 0.0                                             CRS00870
ISN 0066          XZK(IJ) = 0.0                                             CRS00880
ISN 0067          XZJ(IJ) = 0.0                                             CRS00890
ISN 0068          XLK(IJ) = 0.0                                             CRS00900
ISN 0069          XLJ(IJ) = 0.0                                             CRS00910
ISN 0070          XMK(IJ) = 0.0                                             CRS00920
ISN 0071          XMJ(IJ) = 0.0                                             CRS00930
```

Figure 108. (Continued)

```
ISN 0072          XNK(IJ) = 0.0                                       CRS00940
ISN 0073          XNJ(IJ) = 0.0                                       CRS00950
ISN 0074          DXIJ(IJ) = 0.0                                      CRS00960
ISN 0075          DYIJ(IJ) = 0.0                                      CRS00970
ISN 0076          DZIJ(IJ) = 0.0                                      CRS00980
ISN 0077          SEIJ(IJ) = 0.0
ISN 0078          DEIJ(IJ) = 0.0
ISN 0079          DO 160 L = 1,6                                      CRS00990
ISN 0080          SUMDF(L,IJ) = 0.0                                   CRS01000
ISN 0081          N3(IJ,L) = 0                                        CRS01010
ISN 0082          VEEZ(L,IJ) = 0.0                                    CRS01020
ISN 0083          DO 160 K = 1,6                                      CRS01030
ISN 0084          FH3(L,K,IJ) = 0.0                                   CRS01040
ISN 0085      160 FBEAR3(L,K,IJ) = 0.0                                CRS01050
ISN 0086          DO 165 J = 1,3                                      CRS01060
ISN 0087          DO 165 K = 1,3                                      CRS01070
ISN 0088      165 VELDOT(J,K) = 0.0                                   CRS01080
            C DO INITIAL CONDITIONS                                   CRS01090
ISN 0089          CALL IC                                             CRS01100
            C DO ALL THE (AIJ) INTO DIJ                               CRS01110
ISN 0090          CALL DUAIJ                                          CRS01120
ISN 0091          CALL LFRIV                                          CRS01130
ISN 0092          CALL PRINT                                          CRS01140
ISN 0093          IPC = 0                                             CRS01150
ISN 0094          IF(NPLOT.NE.0) CALL SAVE                            CRS01160
ISN 0096          DO 200 I = 1,NM                                     CRS01170
            C PRESET OLD VALUES                                       CRS01180
ISN 0097          PINO(I) = 0.0                                       CRS01190
ISN 0098          QINO(I) = 0.0                                       CRS01200
ISN 0099          RINO(I) = 0.0                                       CRS01210
ISN 0100          XOLD(I) = X(I)                                      CRS01220
ISN 0101          YOLD(I) = Y(I)                                      CRS01230
ISN 0102          ZOLD(I) = Z(I)                                      CRS01240
ISN 0103          PHIOLD(I) = PHI(I)                                  CRS01250
ISN 0104          THEOLD(I) = THETA(I)                                CRS01260
ISN 0105          PSIOLD(I) = PSI(I)                                  CRS01270
ISN 0106          POLD(I) = P(I)                                      CRS01280
ISN 0107          QOLD(I) = Q(I)                                      CRS01290
ISN 0108          ROLD(I) = R(I)                                      CRS01300
ISN 0109          UOLD(I) = U(I)                                      CRS01310
ISN 0110          VOLD(I) = V(I)                                      CRS01320
ISN 0111          WOLD(I) = W(I)                                      CRS01330
            C DO 1ST STEP EULER                                       CRS01340
ISN 0112          DPIN(I) = DELTAT*P(I)                               CRS01350
ISN 0113          DQIN(I) = DELTAT*Q(I)                               CRS01360
ISN 0114          DRIN(I) = DELTAT*R(I)                               CRS01370
ISN 0115          PIN(I) = DPIN(I)                                    CRS01380
ISN 0116          QIN(I) = DQIN(I)                                    CRS01390
ISN 0117          RIN(I) = DRIN(I)                                    CRS01400
ISN 0118          P(I) = P(I)+DELTAT*PDOT(I)                          CRS01410
ISN 0119          Q(I) = Q(I)+DELTAT*QDOT(I)                          CRS01420
ISN 0120          R(I) = R(I)+DELTAT*RDOT(I)                          CRS01430
ISN 0121          U(I) = U(I)+DELTAT*UDOT(I)                          CRS01440
ISN 0122          V(I) = V(I)+DELTAT*VDOT(I)                          CRS01450
```

Figure 108. (Continued)

```
ISN 0123           W(I) = W(I)+DELTAT*WDOT(I)                    CRS01460
ISN 0124           DX(I) = DELTAT*XDOT(I)                        CRS01470
ISN 0125           X(I) = X(I)+DX(I)                             CRS01480
ISN 0126           DY(I) = DELTAT*YDOT(I)                        CRS01490
ISN 0127           Y(I) = Y(I)+DY(I)                             CRS01500
ISN 0128           DZ(I) = DELTAT*ZDOT(I)                        CRS01510
ISN 0129           Z(I) = Z(I)+DZ(I)                             CRS01520
ISN 0130           DPHI(I) = DELTAT*PHIDOT(I)                    CRS01530
ISN 0131           PHI(I) = PHI(I)+DPHI(I)                       CRS01540
ISN 0132           DTHETA(I) = DELTAT*THEDOT(I)                  CRS01550
ISN 0133           THETA(I) = THETA(I)+DTHETA(I)                 CRS01560
ISN 0134           DPSI(I) = DELTAT*PSIDOT(I)                    CRS01570
ISN 0135           PSI(I) = PSI(I)+DPSI(I)                       CRS01580
ISN 0136       200 CONTINUE                                      CRS01590
ISN 0137       190 TIME = TIME+DELTAT                            CRS01600
ISN 0138           CALL DERIV                                    CRS01610
ISN 0139           IPC = IPC+1                                   CRS01620
ISN 0140           IF(IPC-IPRINT) 310,270,270                    CRS01630
ISN 0141       270 CALL PRINT                                    CRS01640
ISN 0142           IPC = 0                                       CRS01650
ISN 0143       310 IF(NPLOT.EQ.0) GO TO 280                      CRS01660
ISN 0145           IPLC = IPLC+1                                 CRS01670
ISN 0146           IF(IPLC.EQ.ITPLOT) CALL SAVE                  CRS01680
             C PREDICT, MOVE DOWN, AND DO DELTA'S                CRS01690
ISN 0148       280 DO 300 I = 1,NM                               CRS01700
ISN 0149           T = PINO(I)+DT2*P(I)                          CRS01710
ISN 0150           PINO(I) = PIN(I)                              CRS01720
ISN 0151           PIN(I) = T                                    CRS01730
ISN 0152           DPIN(I) = PIN(I)-PINO(I)                      CRS01740
ISN 0153           T = QINO(I)+DT2*Q(I)                          CRS01750
ISN 0154           QINO(I) = QIN(I)                              CRS01760
ISN 0155           QIN(I) = T                                    CRS01770
ISN 0156           DQIN(I) = QIN(I)-QINO(I)                      CRS01780
ISN 0157           T = RINO(I)+DT2*R(I)                          CRS01790
ISN 0158           RINO(I) = RIN(I)                              CRS01800
ISN 0159           RIN(I) = T                                    CRS01810
ISN 0160           DRIN(I) = RIN(I)-RINO(I)                      CRS01820
ISN 0161           T = XOLD(I)+DT2*XDOT(I)                       CRS01830
ISN 0162           XOLD(I) = X(I)                                CRS01840
ISN 0163           X(I) = T                                      CRS01850
ISN 0164           DX(I) = X(I)-XOLD(I)                          CRS01860
ISN 0165           T = YOLD(I)+DT2*YDOT(I)                       CRS01870
ISN 0166           YOLD(I) = Y(I)                                CRS01880
ISN 0167           Y(I) = T                                      CRS01890
ISN 0168           DY(I) = Y(I)-YOLD(I)                          CRS01900
ISN 0169           T = ZOLD(I)+DT2*ZDOT(I)                       CRS01910
ISN 0170           ZOLD(I) = Z(I)                                CRS01920
ISN 0171           Z(I) = T                                      CRS01930
ISN 0172           DZ(I) = Z(I)-ZOLD(I)                          CRS01940
ISN 0173           T = PHIOLD(I)+DT2*PHIDOT(I)                   CRS01950
ISN 0174           PHIOLD(I) = PHI(I)                            CRS01960
ISN 0175           PHI(I) = T                                    CRS01970
ISN 0176           DPHI(I) = PHI(I)-PHIOLD(I)                    CRS01980
ISN 0177           T = THEOLD(I)+DT2*THEDOT(I)                   CRS01990
```

Figure 108. (Continued)

```
ISN 0178          THEOLD(I) = THETA(I)                                          CRS02000
ISN 0179          THETA(I) = T                                                  CRS02010
ISN 0180          DTHETA(I) = THETA(I)-THEOLD(I)                                CRS02020
ISN 0181          T = PSIOLD(I)+DT2*PSIDOT(I)                                   CRS02030
ISN 0182          PSIOLD(I) = PSI(I)                                            CRS02040
ISN 0183          PSI(I) = T                                                    CRS02050
ISN 0184          DPSI(I) = PSI(I)-PSIOLD(I)                                    CRS02060
ISN 0185          T = POLD(I)+DT2*PDOT(I)                                       CRS02070
ISN 0186          POLD(I) = P(I)                                                CRS02080
ISN 0187          P(I) = T                                                      CRS02090
ISN 0188          T = QOLD(I)+DT2*QDOT(I)                                       CRS02100
ISN 0189          QOLD(I) = Q(I)                                                CRS02110
ISN 0190          Q(I) = T                                                      CRS02120
ISN 0191          T = ROLD(I)+DT2*RDOT(I)                                       CRS02130
ISN 0192          ROLD(I) = R(I)                                                CRS02140
ISN 0193          R(I) = T                                                      CRS02150
ISN 0194          T = UOLD(I)+DT2*UDOT(I)                                       CRS02160
ISN 0195          UOLD(I) = U(I)                                                CRS02170
ISN 0196          U(I) = T                                                      CRS02180
ISN 0197          T = VOLD(I)+DT2*VDOT(I)                                       CRS02190
ISN 0198          VOLD(I) = V(I)                                                CRS02200
ISN 0199          V(I) = T                                                      CRS02210
ISN 0200          T = WOLD(I)+DT2*WDOT(I)                                       CRS02220
ISN 0201          WOLD(I) = W(I)                                                CRS02230
ISN 0202          W(I) = T                                                      CRS02240
ISN 0203      300 CONTINUE                                                      CRS02250
ISN 0204          IF(TIME-TMAX) 190,190,500                                     CRS02260
ISN 0205      500 IF (KRUPT) 5500,5500,5000                                     CRS02270
ISN 0206     5000 PRINT 2000                                                    CRS02280
ISN 0207     2000 FORMAT(1H1,7X,15HRUPTURE SUMMARY,/)                           CRS02290
ISN 0208          PRINT 3000                                                    CRS02300
ISN 0209     3000 FORMAT(1H ,9X,1HI,9X,1HJ,7X,4HTIME,/)                         CRS02310
ISN 0210          PRINT 4000,(IRUPT(KRT),JRUPT(KRT),TRUPT(KRT),KRT=1,KRUPT)     CRS02320
ISN 0211     4000 FORMAT(1H ,2I10,F10.5)                                        CRS02330
ISN 0212     5500 IF (KPEN.LE.0)  GO TO 6000                                    CRS02340
ISN 0214          PRINT 5501                                                    CRS02350
ISN 0215     5501 FORMAT(1H1,7X,'CONTROL VOLUME PENETRATIONS' //)               CRS02360
ISN 0216          PRINT 5502                                                    CRS02370
ISN 0217     5502 FORMAT(1H ,13X,'TIME',10X,'MASS' /)                           CRS02380
ISN 0218          PRINT 5503,(TPEN(K),IPEN(K),K=1,KPEN)                         CRS02390
ISN 0219     5503 FORMAT(1H ,10X,F10.5,I10)                                     CRS02400
ISN 0220     6000 IF(NPLUT.NE.0) CALL TOLP                                      CRS02410
ISN 0222          GO TO 1                                                       CRS02420
ISN 0223     1000 IF(IPLSW.NE.0) CALL EXITG(ZAR)                                CRS02430
ISN 0225          STOP                                                          CRS02440
ISN 0226          END                                                           CRS02450
```

Figure 108. (Continued)

```
LEVEL 20.1 (MAY 71)                          OS/360  FORTRAN H                                    DATE  73.298/10.02.31

        COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                          SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
  ISN 0002      SUBROUTINE DERIV                                                    CRS02460
  ISN 0003      IMPLICIT REAL*8 (A-H,O-Z)                                           CRS02470
  ISN 0004      REAL*4 XKS,XKI,XKR,AXK,PLOT,ZAR,IMPLOT                              CRS02480
  ISN 0005      INTEGER*2 NLSFLG,PTR*4,CHUG,      IDPLOT,N,IJPK,ISP,      NN,BLANKCRS02490
  ISN 0006      DIMENSION IRUPSW(60),IPENSW(60),SINCOS(6),CIJ(540),DAI(9),DD(6),    CRS02500
               1 DF(6),D(6),AIAIJI(9),AP(9)                                         CRS02510
  ISN 0007      COMMON/DERIN/ XNBAR,XPBAR,YNBAR,YPBAR,ZNBAR,ZPBAR                   CRS02515
  ISN 0008      COMMON/DERIN/HFX(60),HFY(60),HFZ(60),ALIFT(60),VMAX(480),INDP       CRS02520
  ISN 0009      COMMON/LINES/ XKS(1200),XKI(1200),AKR(1200),NLSFLG(480),CHUG(60)    CRS02530
  ISN 0010      COMMON                    XX(60),XY(60),XZ(60),XL(60),XM(60),       CRS00060
               1 XN(60),DPX(60),DPY(60),DPZ(60),DPL(60),DPM(60),DPN(60),            CRS00070
               2 PIN(60),CIN(60),RIN(60),XI1(60),XI2(60),XI3(60),XI4(60),XI5(60),   CRS00080
               3 XI6(60),XXK(80),XYK(80),XZK(80),XLK(60),XMK(80),XNK(60),XXJ(60),   CRS00090
               4 XYJ(80),XZJ(80),XLJ(80),XMJ(80),XNJ(80),                           CRS00100
               5          DELT(60),POLD(60),QOLD(60),ROLD(60),UOLD(60),VOLD(60),    CRS00110
               6 WOLD(60),XOLD(60),YOLD(60),ZOLD(60),PIND(60),CIND(60),RIND(60),    CRS00120
               7 DXIJ(60),DYIJ(60),DZIJ(60),PHIOLD(60),THEOLD(60),PSIOLD(60),       CRS00130
               8 IPEN(60),IRUPT(60),DTHALF,                                         CRS00140
               9 IJKK,KPEN,KRUPT,IPEN(60),IRUPT(60),JRUPT(80)                       CRS00150
  ISN 0011      COMMON/COMALL/ C(6,60),P(60),Q(60),R(60),U(60),V(60),W(60),X(60),   CRS00160
               1 Y(60),Z(60),AI(9),AJ(9),FM(2880),SC(60,3),XC(6),XK(2880),XI(60),   CRS00170
               2 YI(60),ZI(60),XYI(60),XZI(60),YZI(60),AIJ(9),BIJ(540),DIJ(720),    CRS00180
               3 DKI(80),LAI(540),VEE(480),WGT(6),PHI(60),THETA(60),PSI(60),        CRS00190
               4 PDOT(60),QDOT(60),RDOT(60),UDOT(60),VDOT(60),WDOT(60),XDOT(60),    CRS00200
               5 YDOT(60),ZDOT(60),PHIDOT(60),THEDOT(60),PSIDOT(60),TIME,DELTAT,    CRS00210
               6 XACC(60),YACC(60),ZACC(60),AITAJ(9),AIDOT(9),FMBAR(2880),          CRS00220
               7 PHIIJ(60),THEIJ(80),PSIIJ(60),SUMDF(6,60),TITLE(10),XLBAR(60,3),   CRS00230
               8 FSPEAK(60,3),VEEDOT(3,3),DX(60),DY(60),DZ(60),DPIN(60),DRIN(60),   CRS00240
               8 DQIN(60),SEIJ(80),DFIJ(60),CEIK(60,3),
               9ZAR(200),PLOT(50000),IMPLOT(500),                                   CRS02730
               ANM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(150),IG(80),JG(80),      CRS02740
               6 N(480),NN(60,3),ISP(60,3),IJPR(60),IDPLOT(150)                     CRS00270
  ISN 0012      EQUIVALENCE (S1,SINCOS(1)),(C1,SINCOS(2)),(S2,SINCOS(3)),           CRS02770
               1           (C2,SINCOS(4)),(S3,SINCOS(5)),(C3,SINCOS(6))             CRS02780
  ISN 0013      DATA BLANK/'  '/                                                    CRS02781
  ISN 0014      SIN(X) = DSIN(X)                                                    CRS02790
  ISN 0015      COS(X) = DCOS(X)                                                    CRS02800
  ISN 0016      TT = .200                                                           CRS02810
  ISN 0017      ET = .600                                                           CRS02820
  ISN 0018      IF(TIME.NE.0.0) GO TO 60                                            CRS02830
  ISN 0020      DO 70 IJ = 1,IGS                                                    CRS02840
```

Figure 108. (Continued)

```
ISN 0021       70 IFUPSW(IJ) = 0                                   CRS02850
ISN 0022          DO 72 I=1,NM                                     CRS02860
ISN 0023       72 IPENSW(I)=0                                      CRS02870
            C DO ALL THE (AI)((AJ))                                CRS02880
ISN 0024       60 DO 10 I = 1,NM                                   CRS02890
ISN 0025          ARG = PHI(I)                                     CRS02900
ISN 0026          S1 = SIN(ARG)                                    CRS02910
ISN 0027          C1 = COS(ARG)                                    CRS02920
ISN 0028          ARG = THETA(I)                                   CRS02930
ISN 0029          S2 = SIN(ARG)                                    CRS02940
ISN 0030          C2 = COS(ARG)                                    CRS02950
ISN 0031          ARG = PSI(I)                                     CRS02960
ISN 0032          S3 = SIN(ARG)                                    CRS02970
ISN 0033          C3 = COS(ARG)                                    CRS02980
ISN 0034          DO 40 J = 1,6                                    CRS02990
ISN 0035          T = SINCOS(J)                                    CRS03000
ISN 0036          IF(T) 45,40,50                                   CRS03010
ISN 0037       45 T = -T                                           CRS03020
ISN 0038       50 IF(T-1.E-10) 55,40,40                            CRS03030
ISN 0039       55 SINCOS(J) = 0.0                                  CRS03040
ISN 0040       40 CONTINUE                                         CRS03050
            C                                                      CRS03060
ISN 0041          J = 9*(I-1)                                      CRS03070
            C MOVE AI S TO OLD AI S                                CRS03080
ISN 0042          DO 4 JJ = 1,9                                    CRS03090
ISN 0043        4 OAI(J+JJ) = BIJ(J+JJ)                            CRS03100
ISN 0044          S1S2 = S1*S2                                     CRS03110
ISN 0045          C1S2 = C1*S2                                     CRS03120
ISN 0046          AI(1) = C2*C3                                    CRS03130
ISN 0047          BIJ(J+1) = AI(1)                                 CRS03140
ISN 0048          AI(2) = C2*S3                                    CRS03150
ISN 0049          BIJ(J+2) = AI(2)                                 CRS03160
ISN 0050          AI(3) = -S2                                      CRS03170
ISN 0051          BIJ(J+3) = AI(3)                                 CRS03180
ISN 0052          AI(4) = -C1*S3+S1S2*C3                           CRS03190
ISN 0053          BIJ(J+4) = AI(4)                                 CRS03200
ISN 0054          AI(5) = C1*C3+S1S2*S3                            CRS03210
ISN 0055          BIJ(J+5) = AI(5)                                 CRS03220
ISN 0056          AI(6) = S1*C2                                    CRS03230
ISN 0057          BIJ(J+6) = AI(6)                                 CRS03240
ISN 0058          AI(7) = S1*S3+C1S2*C3                            CRS03250
ISN 0059          BIJ(J+7) = AI(7)                                 CRS03260
ISN 0060          AI(8) = -S1*C3+C1S2*S3                           CRS03270
ISN 0061          BIJ(J+8) = AI(8)                                 CRS03280
ISN 0062          AI(9) = C1*C2                                    CRS03290
ISN 0063          BIJ(J+9) = AI(9)                                 CRS03300
            C (27)                                                 CRS03310
ISN 0064          PP = P(I)                                        CRS03320
ISN 0065          QQ = Q(I)                                        CRS03330
ISN 0066          RR = R(I)                                        CRS03340
ISN 0067          UU = U(I)                                        CRS03350
ISN 0068          VV = V(I)                                        CRS03360
ISN 0069          WW = W(I)                                        CRS03370
ISN 0070          XDOTI = XDOT(I)                                  CRS03380
```

Figure 108. (Continued)

```
ISN 0071          XDOT(I) = AI(1)*UU+AI(4)*VV+AI(7)*WW                       CRS03390
ISN 0072          YDOTI = YDOT(I)                                            CRS03400
ISN 0073          YDOT(I) = AI(2)*UU+AI(5)*VV+AI(8)*WW                       CRS03410
ISN 0074          ZDOTI = ZDOT(I)                                            CRS03420
ISN 0075          ZDOT(I) = AI(3)*UU+AI(6)*VV+AI(9)*WW                       CRS03430
            C (28),(29)                                                      CRS03440
ISN 0076          CS = S1/C2                                                 CRS03450
ISN 0077          CC = C1/C2                                                 CRS03460
ISN 0078          PHDOTI = PHIDOT(I)                                         CRS03470
ISN 0079          PHIDOT(I) = PP+QQ*CS*S2+RR*CC*S2                           CRS03480
ISN 0080          THDOTI = THEDOT(I)                                         CRS03490
ISN 0081          THEDOT(I) = QQ*C1-RR*S1                                    CRS03500
ISN 0082          PSDOTI = PSIDOT(I)                                         CRS03510
ISN 0083          PSIDOT(I) = QQ*CS+RR*CC                                    CRS03520
            C DO AIDOT NOW                                                   CRS03530
ISN 0084          T = PSIDOT(I)*C2                                           CRS03540
ISN 0085          T1 = THEDOT(I)*S1-T*C1                                     CRS03550
ISN 0086          T2 = THEDOT(I)*C1+T*S1                                     CRS03560
ISN 0087          T3 = PHIDOT(I)-PSIDOT(I)*S2                                CRS03570
ISN 0088          CIJ(J+1)= -BIJ(J+4)*T1-BIJ(J+7)*T2                         CRS03580
ISN 0089          CIJ(J+4)=  BIJ(J+1)*T1+BIJ(J+7)*T3                         CRS03590
ISN 0090          CIJ(J+7)=  BIJ(J+1)*T2-BIJ(J+4)*T3                         CRS03600
ISN 0091          CIJ(J+2)= -BIJ(J+5)*T1-BIJ(J+8)*T2                         CRS03610
ISN 0092          CIJ(J+5)=  BIJ(J+2)*T1+BIJ(J+8)*T3                         CRS03620
ISN 0093          CIJ(J+8)=  BIJ(J+2)*T2-BIJ(J+5)*T3                         CRS03630
ISN 0094          CIJ(J+3)= -BIJ(J+6)*T1-BIJ(J+9)*T2                         CRS03640
ISN 0095          CIJ(J+6)=  BIJ(J+3)*T1+BIJ(J+9)*T3                         CRS03650
ISN 0096          CIJ(J+9)=  BIJ(J+3)*T2-BIJ(J+6)*T3                         CRS03660
ISN 0097          IF(TIME) 10,10,5                                           CRS03670
            C CORRECT X,Y,Z,PHI,THETA,PSI                                    CRS03680
ISN 0098        5 X(I) = TT*X(I)+ET*(XOLD(I)+DTHALF*(XDOT(I)+XDOTI))         CRS03690
ISN 0099          Y(I) = TT*Y(I)+ET*(YOLD(I)+DTHALF*(YDOT(I)+YDOTI))         CRS03700
ISN 0100          Z(I) = TT*Z(I)+ET*(ZOLD(I)+DTHALF*(ZDOT(I)+ZDOTI))         CRS03710
ISN 0101          PHI(I) = TT*PHI(I)+ET*(PHIOLD(I)+DTHALF*(PHIDOT(I)+PHDOTI))  CRS03720
ISN 0102          THETA(I) = TT*THETA(I)+ET*(THEOLD(I)+DTHALF*(THEDOT(I)+THDOTI))  CRS03730
ISN 0103          PSI(I) = TT*PSI(I)+ET*(PSIOLD(I)+DTHALF*(PSIDOT(I)+PSDOTI))  CRS03740
            C CLEAR THE DAMPING TERMS.                                       CRS03750
ISN 0104          DPX(I) = 0.0                                               CRS03760
ISN 0105          DPY(I) = 0.0                                               CRS03770
ISN 0106          DPZ(I) = 0.0                                               CRS03780
ISN 0107          DPL(I) = 0.0                                               CRS03790
ISN 0108          DPM(I) = 0.0                                               CRS03800
ISN 0109          DPN(I) = 0.0                                               CRS03810
ISN 0110       10 CONTINUE                                                   CRS03820
            C DO 1000 IS MAIN DO LOOP TO GET TOTAL INTERNAL FORCES AND MOMENTS  CRS03830
ISN 0111          ILAST = 0                                                  CRS03840
ISN 0112          IJLIJ = 0                                                  CRS03850
ISN 0113          IJKLIJ = -36                                               CRS03860
ISN 0114          DO 1000 IJ = 1,IGS                                         CRS03870
ISN 0115          IJKLIJ = IJKLIJ+36                                         CRS03880
ISN 0116          IJKK = IJKLIJ-6                                            CRS03890
ISN 0117          IJLIJ = IJLIJ+6                                            CRS03900
ISN 0118          IJL = IJLIJ                                                CRS03910
ISN 0119          IF(IRUPSW(IJ).NE.0) GO TO 1000                             CRS03920
```

Figure 108. (Continued)

```
ISN 0121          I = IG(IJ)                                                    CRS03930
ISN 0122          J = JG(IJ)                                                    CRS03940
          C IF WE GET TO A NEW I WE MUST MOVE (AI) INTO AI AND (AIDOT) INTO AIDOT CRS03950
ISN 0123          IF(I-ILAST) 20,30,20                                          CRS03960
ISN 0124       20 ILAST = 1                                                     CRS03970
ISN 0125          IS = 9*(I-1)                                                  CRS03980
ISN 0126          DO 320 KS = 1,9                                               CRS03990
ISN 0127          IS = IS+1                                                     CRS04000
ISN 0128          AIDOT(KS) = CIJ(IS)                                           CRS04010
ISN 0129          DAI(KS) = DAI(IS)-BIJ(IS)                                     CRS04020
ISN 0120      320 AI(KS) = BIJ(IS)                                              CRS04030
ISN 0131       30 XIJ = X(J)-X(I)                                               CRS04040
ISN 0132          YIJ = Y(J)-Y(I)                                               CRS04050
ISN 0133          ZIJ = Z(J)-Z(I)                                               CRS04060
ISN 0134          XIJO = OXIJ(IJ)                                               CRS04070
ISN 0135          YIJO = OYIJ(IJ)                                               CRS04080
ISN 0136          ZIJO = OZIJ(IJ)                                               CRS04090
ISN 0137          OXIJ(IJ) = XIJ                                                CRS04100
ISN 0138          OYIJ(IJ) = YIJ                                                CRS04110
ISN 0139          OZIJ(IJ) = ZIJ                                                CRS04120
          C                                                                     CRS04130
ISN 0140          IS = 9*(J-1)                                                  CRS04140
ISN 0141          IJS = 9*(IJ-1)                                                CRS04150
ISN 0142          DO 310 KS = 1,9                                               CRS04160
ISN 0143          IS = IS+1                                                     CRS04170
ISN 0144          IJS = IJS+1                                                   CRS04180
ISN 0145          AIJ(KS) = DIJ(IJS)                                            CRS04190
ISN 0146      310 AJ(KS) = BIJ(IS)                                              CRS04200
          C (4)                                                                 CRS04210
ISN 0147          T1 = DX(J)-DX(I)                                              CRS04220
ISN 0148          T2 = DY(J)-DY(I)                                              CRS04230
ISN 0149          T3 = DZ(J)-DZ(I)                                              CRS04240
          C (5)                                                                 CRS04250
ISN 0150          T4= AI(1)*T1+AI(2)*T2+AI(3)*T3-DAI(1)*XIJO-DAI(2)*YIJO-DAI(3)*ZIJOCRS04260
ISN 0151          T5= AI(4)*T1+AI(5)*T2+AI(6)*T3-DAI(4)*XIJO-DAI(5)*YIJO-DAI(6)*ZIJOCRS04270
ISN 0152          T6= AI(7)*T1+AI(8)*T2+AI(9)*T3-DAI(7)*XIJO-DAI(8)*YIJO-DAI(9)*ZIJOCRS04280
ISN 0153          D(1) = AIJ(1)*T4+AIJ(2)*T5+AIJ(3)*T6                          CRS04290
ISN 0154          D(2) = AIJ(4)*T4+AIJ(5)*T5+AIJ(6)*T6                          CRS04300
ISN 0155          D(3) = AIJ(7)*T4+AIJ(8)*T5+AIJ(9)*T6                          CRS04310
          C (9)                                                                 CRS04320
ISN 0156          AITAJ(1) = AI(1)*AJ(1)+AI(2)*AJ(2)+AI(3)*AJ(3)                CRS04330
ISN 0157          AITAJ(2) = AI(4)*AJ(1)+AI(5)*AJ(2)+AI(6)*AJ(3)                CRS04340
ISN 0158          AITAJ(3) = AI(7)*AJ(1)+AI(8)*AJ(2)+AI(9)*AJ(3)                CRS04350
ISN 0159          AITAJ(4) = AI(1)*AJ(4)+AI(2)*AJ(5)+AI(3)*AJ(6)                CRS04360
ISN 0160          AITAJ(5) = AI(4)*AJ(4)+AI(5)*AJ(5)+AI(6)*AJ(6)                CRS04370
ISN 0161          AITAJ(6) = AI(7)*AJ(4)+AI(8)*AJ(5)+AI(9)*AJ(6)                CRS04380
ISN 0162          AITAJ(7) = AI(1)*AJ(7)+AI(2)*AJ(8)+AI(3)*AJ(9)                CRS04390
ISN 0163          AITAJ(8) = AI(4)*AJ(7)+AI(5)*AJ(8)+AI(6)*AJ(9)                CRS04400
ISN 0164          AITAJ(9) = AI(7)*AJ(7)+AI(8)*AJ(8)+AI(9)*AJ(9)                CRS04410
ISN 0165          T1 = DPIN(J)                                                  CRS04420
ISN 0166          T2 = DQIN(J)                                                  CRS04430
ISN 0167          T3 = DRIN(J)                                                  CRS04440
ISN 0168          T4 = T1*AITAJ(1)+T2*AITAJ(4)+T3*AITAJ(7)-DPIN(I)              CRS04450
ISN 0169          T5 = T1*AITAJ(2)+T2*AITAJ(5)+T3*AITAJ(8)-DQIN(I)              CRS04460
```

Figure 108. (Continued)

```
ISN 0170          T6 = T1*AITAJ(3)+T2*AITAJ(6)+T3*AITAJ(9)-DRIN(I)          CRS04470
            C (9R)                                                          CRS04480
ISN 0171          D(4) = AIJ(1)*T4+AIJ(2)*T5+AIJ(3)*T6                      CRS04490
ISN 0172          D(5) = AIJ(4)*T4+AIJ(5)*T5+AIJ(6)*T6                      CRS04500
ISN 0173          D(6) = AIJ(7)*T4+AIJ(8)*T5+AIJ(9)*T6                      CRS04510
ISN 0174          DD(1) = D(1)/DELTAT
ISN 0175          DD(2) = D(2)/DELTAT
ISN 0176          DD(3) = D(3)/DELTAT
ISN 0177          T1 = P(J)                                                 CRS04610
ISN 0178          T2 = Q(J)                                                 CRS04620
ISN 0179          T3 = R(J)                                                 CRS04630
ISN 0180          T4 = T1*AITAJ(1)+T2*AITAJ(4)+T3*AITAJ(7)-P(I)             CRS04640
ISN 0181          T5 = T1*AITAJ(2)+T2*AITAJ(5)+T3*AITAJ(8)-Q(I)             CRS04650
ISN 0182          T6 = T1*AITAJ(3)+T2*AITAJ(6)+T3*AITAJ(9)-R(I)             CRS04660
ISN 0183          DD(4) = T4*AIJ(1)+T5*AIJ(2)+T6*AIJ(3)                     CRS04670
ISN 0184          DD(5) = T4*AIJ(4)+T5*AIJ(5)+T6*AIJ(6)                     CRS04680
ISN 0185          DD(6) = T4*AIJ(7)+T5*AIJ(8)+T6*AIJ(9)                     CRS04690
ISN 0186          DO 270 K = 1,6                                            CRS04700
ISN 0187      270 DD(K) = C(K,IJ)*DD(K)                                     CRS04710
            C*****DVSIGN IS NO LONGER USED.                                 CRS04720
            C*****FMBAR HAS VHBAR(I,J,K,L) IN IT NOW (7AUG1972)             CRS04730
ISN 0188          DO 150 K = 1,6                                            CRS04740
ISN 0189          IJKK = IJKK+6                                             CRS04750
ISN 0190          IJKL = IJKK                                               CRS04760
ISN 0191          IJL = IJL-6                                               CRS04770
ISN 0192          DF(K) = 0.0                                               CRS04780
ISN 0193          DO 150 L = 1,6                                            CRS04790
ISN 0194          IJKL = IJKL+1                                             CRS04800
ISN 0195          IJL = IJL+1                                               CRS04810
ISN 0196          T = XK(IJKL)                                              CRS04820
ISN 0197          IF(T) 160,150,160                                         CRS04830
ISN 0198      160 A = D(L)                                                  CRS04840
ISN 0199          B = A*VEE(IJL)                                            CRS04850
ISN 0200          IF(A.GE.0.0.AND.B.GE.0.0.OR.A.LT.0.0.AND.B.LT.0.0) GO TO 210  CRS04860
            C SIGNS NOT SAME                                                CRS04870
ISN 0202          IF(N(IJL)) 180,180,190                                    CRS04880
ISN 0203      180 N(IJL) = 1                                                CRS04890
ISN 0204          FMBAR(IJKL) = DABS(VEE(IJL))                              CRS04900
ISN 0205      190 DELFM = T*A                                               CRS04910
ISN 0206          GO TO 220                                                 CRS04920
            C SIGNS THE SAME                                                CRS04930
ISN 0207      210 VP = DABS(VEE(IJL))                                       CRS04940
ISN 0208          IF(VP.LT.FMBAR(IJKL)) GO TO 190                           CRS04950
ISN 0210          N(IJL) = 0                                                CRS04960
            C*****USE A TABLE IF PRESENT                                    CRS04970
ISN 0211          ITN = NLSFLG(IJL)                                         CRS04980
ISN 0212          IF(ITN.EQ.0) GO TO 190                                    CRS04990
ISN 0214          AXK = VP                                                  CRS05000
ISN 0215          PTR = CHGG(ITN)                                           CRS05010
ISN 0216          IF(AXK.LT.XKR(PTR)) GO TO 110                             CRS05020
ISN 0218          IF(AXK.GT.XKR(PTR+1)) GO TO 120                           CRS05030
ISN 0220      140 DELFM = (XKS(PTR)*AXK+XKI(PTR))*T*A                       CRS05040
ISN 0221          GO TO 220                                                 CRS05050
            C*****REFER TO EXPLANATION IN SUBROUTINE INPUT FOR WHY THESE LOOPS  CRS05060
```

Figure 108. (Continued)

```
                C ARE SAFE TO BE SO TIGHT.                                        CRS05070
                C*****CHUG DOWN                                                   CRS05080
  ISN 0222        110 PTR = PTR-1                                                 CRS05090
  ISN 0223            IF(ARK.LT.XKR(PTR)) GO TO 110                               CRS05100
  ISN 0225        130 CHUG(IIN) = PTR                                             CRS05110
  ISN 0226            GO TO 140                                                   CRS05120
                C*****CHUG UP                                                     CRS05130
  ISN 0227        120 PTR = PTR+1                                                 CRS05140
  ISN 0228            IF(FXK.GT.XKR(PTR+1)) GO TO 120                             CRS05150
  ISN 0230            GO TO 130                                                   CRS05160
  ISN 0231        220 FM(IJKL) = FM(IJKL)+DELFM                                   CRS05170
  ISN 0232            DF(K) = DF(K)+DELFM                                         CRS05180
  ISN 0233        150 CONTINUE                                                    CRS05190
  ISN 0234            DO 630 K = 1,6                                              CRS05200
  ISN 0235        630 SUMDF(K,IJ) = SUMDF(K,IJ)+DF(K)                             CRS05210
                C*****COMPUTE THE ENERGY HERE BUT ADD IT AFTER 230 (NO RUPTURE)
  ISN 0236            SUMSE = 0.0
  ISN 0237            SUMDE = 0.0
                C*****DON'T USE AN IJ IF IT'S A DRI ELEMENT
  ISN 0238            IF(IJPK(IJ).NE.BLANK) GO TO 632
  ISN 0240            DO 631 K = 1,6
  ISN 0241            SUMSE = SUMSE+SUMDF(K,IJ)*D(K)
  ISN 0242        631 SUMDE = SUMDE+DD(K)*D(K)
  ISN 0243            IF (IJ.NE.4) GO TO 632
  ISN 0245            PRINT 999, (DD(K),D(K),K=1,6)
  ISN 0246        999 FORMAT(1X,1P12F11.3)
  ISN 0247        632 IJL = IJL-6                                                 CRS05220
  ISN 0248            DO 230 L = 1,6                                              CRS05230
  ISN 0249            IJL = IJL+1                                                 CRS05240
  ISN 0250            T = VEE(IJL)+D(L)                                           CRS05250
  ISN 0251            VEE(IJL) = T                                                CRS05260
                C MOVE DF TO D FOR (13) ETC.                                      CRS05270
  ISN 0252            D(L) = DF(L)                                                CRS05280
  ISN 0253            IF(T) 240,250,250                                           CRS05290
  ISN 0254        240 T = -T                                                      CRS05300
  ISN 0255        250 IF(T-VMAX(IJL)) 230,260,260                                 CRS05310
  ISN 0256        260 IRUPSW(IJ) = 1                                              CRS05320
  ISN 0257            XX(I) = XX(I)-XXK(IJ)                                       CRS05330
  ISN 0258            XY(I) = XY(I)-XYK(IJ)                                       CRS05340
  ISN 0259            XZ(I) = XZ(I)-XZK(IJ)                                       CRS05350
  ISN 0260            XL(I) = XL(I)-XLK(IJ)                                       CRS05360
  ISN 0261            XM(I) = XM(I)-XMK(IJ)                                       CRS05370
  ISN 0262            XN(I) = XN(I)-XNK(IJ)                                       CRS05380
  ISN 0263            XX(J) = XX(J)-XXJ(IJ)                                       CRS05390
  ISN 0264            XY(J) = XY(J)-XYJ(IJ)                                       CRS05400
  ISN 0265            XZ(J) = XZ(J)-XZJ(IJ)                                       CRS05410
  ISN 0266            XL(J) = XL(J)-XLJ(IJ)                                       CRS05420
  ISN 0267            XM(J) = XM(J)-XMJ(IJ)                                       CRS05430
  ISN 0268            XN(J) = XN(J)-XNJ(IJ)                                       CRS05440
  ISN 0269            KRUPT = KRUPT+1                                             CRS05450
  ISN 0270            IRUPT(KRUPT) = I                                            CRS05460
  ISN 0271            JRUPT(KRUPT) = J                                            CRS05470
  ISN 0272            TRUPT(KRUPT) = TIME                                         CRS05480
  ISN 0273            PRINT 1040, IJ,L,VEE(IJL),VMAX(IJL)                         CRS05490
```

Figure 108. (Continued)

```
ISN 0274    1040 FORMAT(1H1*RUPTURE *2I5,1P2E15.6)                      CRS05500
ISN 0275         GO TO 1000                                              CRS05510
ISN 0276     230 CONTINUE                                                CRS05520
ISN 0277         SETJ(IJ) = SETJ(IJ)+SUMSE
ISN 0278         DETJ(IJ) = DETJ(IJ)+SUMDE
ISN 0279         IF (IJPR(IJ).NE.BLANK)  DR(IJ) = -6.55D0*VEE(IJL-5)     CRS05530
ISN 0281         AIAIJT(1) = AI(1)*AIJ(1)+AI(4)*AIJ(2)+AI(7)*AIJ(3)      CRS05540
ISN 0282         AIAIJT(4) = AI(1)*AIJ(4)+AI(4)*AIJ(5)+AI(7)*AIJ(6)      CRS05550
ISN 0283         AIAIJT(7) = AI(1)*AIJ(7)+AI(4)*AIJ(8)+AI(7)*AIJ(9)      CRS05560
ISN 0284         AIAIJT(2) = AI(2)*AIJ(1)+AI(5)*AIJ(2)+AI(8)*AIJ(3)      CRS05570
ISN 0285         AIAIJT(5) = AI(2)*AIJ(4)+AI(5)*AIJ(5)+AI(8)*AIJ(6)      CRS05580
ISN 0286         AIAIJT(8) = AI(2)*AIJ(7)+AI(5)*AIJ(8)+AI(8)*AIJ(9)      CRS05590
ISN 0287         AIAIJT(3) = AI(3)*AIJ(1)+AI(6)*AIJ(2)+AI(9)*AIJ(3)      CRS05600
ISN 0288         AIAIJT(6) = AI(3)*AIJ(4)+AI(6)*AIJ(5)+AI(9)*AIJ(6)      CRS05610
ISN 0289         AIAIJT(9) = AI(3)*AIJ(7)+AI(6)*AIJ(8)+AI(9)*AIJ(9)      CRS05620
            C (13A)                                                      CRS05630
ISN 0290         T1 = AIAIJT(1)*D(1)+AIAIJT(4)*D(2)+AIAIJT(7)*D(3)       CRS05640
ISN 0291         T2 = AIAIJT(2)*D(1)+AIAIJT(5)*D(2)+AIAIJT(8)*D(3)       CRS05650
ISN 0292         T3 = AIAIJT(3)*D(1)+AIAIJT(6)*D(2)+AIAIJT(9)*D(3)       CRS05660
ISN 0293         D(1) = T1                                               CRS05670
ISN 0294         D(2) = T2                                               CRS05680
ISN 0295         D(3) = T3                                               CRS05690
            C (13B)                                                      CRS05700
ISN 0296         T1 = AIAIJT(1)*D(4)+AIAIJT(4)*D(5)+AIAIJT(7)*D(6)       CRS05710
ISN 0297         T2 = AIAIJT(2)*D(4)+AIAIJT(5)*D(5)+AIAIJT(8)*D(6)       CRS05720
ISN 0298         T3 = AIAIJT(3)*D(4)+AIAIJT(6)*D(5)+AIAIJT(9)*D(6)       CRS05730
ISN 0299         D(4) = T1                                               CRS05740
ISN 0300         D(5) = T2                                               CRS05750
ISN 0301         D(6) = T3                                               CRS05760
            C (17A)                                                      CRS05770
ISN 0302         DXX = -(AJ(1)*D(1)+AJ(2)*D(2)+AJ(3)*D(3))               CRS05780
ISN 0303         DXY = -(AJ(4)*D(1)+AJ(5)*D(2)+AJ(6)*D(3))               CRS05790
ISN 0304         DXZ = -(AJ(7)*D(1)+AJ(8)*D(2)+AJ(9)*D(3))               CRS05800
ISN 0305         XX(J) = XX(J)+DXX                                       CRS05810
ISN 0306         XY(J) = XY(J)+DXY                                       CRS05820
ISN 0307         XZ(J) = XZ(J)+DXZ                                       CRS05830
ISN 0308         XXJ(IJ) = XXJ(IJ)+DXX                                   CRS05840
ISN 0309         XYJ(IJ) = XYJ(IJ)+DXY                                   CRS05850
ISN 0310         XZJ(IJ) = XZJ(IJ)+DXZ                                   CRS05860
            C (17B)                                                      CRS05870
ISN 0311         DXL = -(AJ(1)*D(4)+AJ(2)*D(5)+AJ(3)*D(6))               CRS05880
ISN 0312         DXM = -(AJ(4)*D(4)+AJ(5)*D(5)+AJ(6)*D(6))               CRS05890
ISN 0313         DXN = -(AJ(7)*D(4)+AJ(8)*D(5)+AJ(9)*D(6))               CRS05900
ISN 0314         XL(J) = XL(J)+DXL                                       CRS05910
ISN 0315         XM(J) = XM(J)+DXM                                       CRS05920
ISN 0316         XN(J) = XN(J)+DXN                                       CRS05930
ISN 0317         XLJ(IJ) = XLJ(IJ)+DXL                                   CRS05940
ISN 0318         XMJ(IJ) = XMJ(IJ)+DXM                                   CRS05950
ISN 0319         XNJ(IJ) = XNJ(IJ)+DXN                                   CRS05960
ISN 0320         IF (IJPR(IJ).NE.BLANK)  GO TO 700                       CRS05970
            C (14B)                                                      CRS05980
ISN 0322         D(4) = D(4)-ZIJ*D(2)+YIJ*D(3)                           CRS05990
ISN 0323         D(5) = D(5)+ZIJ*D(1)-XIJ*D(3)                           CRS06000
ISN 0324         D(6) = D(6)-YIJ*D(1)+XIJ*D(2)                           CRS06010
```

Figure 108. (Continued)

```
      C (16A)                                                         CRS06020
ISN 0325       DXX = AI(1)*D(1)+AI(2)*D(2)+AI(3)*D(3)                CRS06030
ISN 0326       DXY = AI(4)*D(1)+AI(5)*D(2)+AI(6)*D(3)                CRS06040
ISN 0327       DXZ = AI(7)*D(1)+AI(8)*D(2)+AI(9)*D(3)                CRS06050
ISN 0328       XX(I) = XX(I)+DXX                                      CRS06060
ISN 0329       XY(I) = XY(I)+DXY                                      CRS06070
ISN 0330       XZ(I) = XZ(I)+DXZ                                      CRS06080
ISN 0331       XXK(IJ) = XXK(IJ)+DXX                                  CRS06090
ISN 0332       XYK(IJ) = XYK(IJ)+DXY                                  CRS06100
ISN 0333       XZK(IJ) = XZK(IJ)+DXZ                                  CRS06110
      C (16B)                                                         CRS06120
ISN 0334       DXL = AI(1)*D(4)+AI(2)*D(5)+AI(3)*D(6)                CRS06130
ISN 0335       DXM = AI(4)*D(4)+AI(5)*D(5)+AI(6)*D(6)                CRS06140
ISN 0336       DXN = AI(7)*D(4)+AI(8)*D(5)+AI(9)*D(6)                CRS06150
ISN 0337       XL(I) = XL(I)+DXL                                      CRS06160
ISN 0338       XM(I) = XM(I)+DXM                                      CRS06170
ISN 0339       XN(I) = XN(I)+DXN                                      CRS06180
ISN 0340       XLK(IJ) = XLK(IJ)+DXL                                  CRS06190
ISN 0341       XMK(IJ) = XMK(IJ)+DXM                                  CRS06200
ISN 0342       XNK(IJ) = XNK(IJ)+DXN                                  CRS06210
      C (6A)                                                          CRS06220
ISN 0343   700 CONTINUE                                               CRS06230
ISN 0344       T1 = AIAIJT(1)*DD(1)+AIAIJT(4)*DD(2)+AIAIJT(7)*DD(3)  CRS06240
ISN 0345       T2 = AIAIJT(2)*DD(1)+AIAIJT(5)*DD(2)+AIAIJT(8)*DD(3)  CRS06250
ISN 0346       T3 = AIAIJT(3)*DD(1)+AIAIJT(6)*DD(2)+AIAIJT(9)*DD(3)  CRS06260
ISN 0347       DD(1) = T1                                             CRS06270
ISN 0348       DD(2) = T2                                             CRS06280
ISN 0349       DD(3) = T3                                             CRS06290
      C (6B)                                                          CRS06300
ISN 0350       T1 = AIAIJT(1)*DD(4)+AIAIJT(4)*DD(5)+AIAIJT(7)*DD(6)  CRS06310
ISN 0351       T2 = AIAIJT(2)*DD(4)+AIAIJT(5)*DD(5)+AIAIJT(8)*DD(6)  CRS06320
ISN 0352       T3 = AIAIJT(3)*DD(4)+AIAIJT(6)*DD(5)+AIAIJT(9)*DD(6)  CRS06330
ISN 0353       DD(4) = T1                                             CRS06340
ISN 0354       DD(5) = T2                                             CRS06350
ISN 0355       DD(6) = T3                                             CRS06360
      C (9A)                                                          CRS06370
ISN 0356       DXX = -(AJ(1)*DD(1)+AJ(2)*DD(2)+AJ(3)*DD(3))          CRS06380
ISN 0357       DXY = -(AJ(4)*DD(1)+AJ(5)*DD(2)+AJ(6)*DD(3))          CRS06390
ISN 0358       DXZ = -(AJ(7)*DD(1)+AJ(8)*DD(2)+AJ(9)*DD(3))          CRS06400
ISN 0359       DPX(J) = DPX(J)+DXX                                    CRS06410
ISN 0360       DPY(J) = DPY(J)+DXY                                    CRS06420
ISN 0361       DPZ(J) = DPZ(J)+DXZ                                    CRS06430
      C (9B)                                                          CRS06440
ISN 0362       DXL = -(AJ(1)*DD(4)+AJ(2)*DD(5)+AJ(3)*DD(6))          CRS06450
ISN 0363       DXM = -(AJ(4)*DD(4)+AJ(5)*DD(5)+AJ(6)*DD(6))          CRS06460
ISN 0364       DXN = -(AJ(7)*DD(4)+AJ(8)*DD(5)+AJ(9)*DD(6))          CRS06470
ISN 0365       DPL(J) = DPL(J)+DXL                                    CRS06480
ISN 0366       DPM(J) = DPM(J)+DXM                                    CRS06490
ISN 0367       DPN(J) = DPN(J)+DXN                                    CRS06500
ISN 0368       IF (IJPK(IJ).NE.BLANK)  GO TO 1000                     CRS06510
      C (7)                                                           CRS06520
ISN 0370       DD(4) = DD(4)-ZIJ*DD(2)+YIJ*DD(3)                      CRS06530
ISN 0371       DD(5) = DD(5)+ZIJ*DD(1)-XIJ*DD(3)                      CRS06540
ISN 0372       DD(6) = DD(6)-YIJ*DD(1)+XIJ*DD(2)                      CRS06550
```

Figure 108. (Continued)

```
                 C (8A)                                                                    CRS06560
ISN 0373              DXX = AI(1)*DD(1)+AI(2)*DD(2)+AI(3)*DD(3)                            CRS06570
ISN 0374              DXY = AI(4)*DD(1)+AI(5)*DD(2)+AI(6)*DD(3)                            CRS06580
ISN 0375              DXZ = AI(7)*DD(1)+AI(8)*DD(2)+AI(9)*DD(3)                            CRS06590
ISN 0376              DPX(I) = DPX(I)+DXX                                                  CRS06600
ISN 0377              DPY(I) = DPY(I)+DXY                                                  CRS06610
ISN 0378              DPZ(I) = DPZ(I)+DXZ                                                  CRS06620
                 C (8B)                                                                    CRS06630
ISN 0379              DXL = AI(1)*DD(4)+AI(2)*DD(5)+AI(3)*DD(6)                            CRS06640
ISN 0380              DXM = AI(4)*DD(4)+AI(5)*DD(5)+AI(6)*DD(6)                            CRS06650
ISN 0381              DXN = AI(7)*DD(4)+AI(8)*DD(5)+AI(9)*DD(6)                            CRS06660
ISN 0382              DPL(I) = DPL(I)+DXL                                                  CRS06670
ISN 0383              DPM(I) = DPM(I)+DXM                                                  CRS06680
ISN 0384              DPN(I) = DPN(I)+DXN                                                  CRS06690
ISN 0385         1000 CONTINUE                                                             CRS06700
ISN 0386              IS=9*(INDP-1)                                                        CRS06710
ISN 0387              DO 1010 KS=1,9                                                       CRS06720
ISN 0388              IS=IS+1                                                              CRS06730
ISN 0389         1010 AP(KS)=BIJ(IS)                                                       CRS06740
                 C FINISH COMPUTING DERIVATIVES                                            CRS06750
ISN 0390              DO 2000 I = 1,NM                                                     CRS06760
ISN 0391              IS = 9*(I-1)                                                         CRS06770
ISN 0392              DO 330 KS = 1,9                                                      CRS06780
ISN 0393              IS = IS+1                                                            CRS06790
ISN 0394              AIDOT(KS) = CIJ(IS)                                                  CRS06800
ISN 0395          330 AI(KS) = BIJ(IS)                                                     CRS06810
                 C DO CRASH FORCES                                                         CRS06820
ISN 0396              DO 340 K = 1,6
ISN 0397          340 XC(K) = 0.0
ISN 0398              IF(ISP(I,1).EQ.1 .OR.ISP(I,2).EQ.1.OR.ISP(I,3).EQ.1) CALL CFORCE
                 C (20),(23),(24)                                                          CRS06840
ISN 0400              XA = WGT(I)-ALIFT(I)                                                 CRS06850
ISN 0401              SX = XX(I)+XA*AI(3)+XC(1)+DPX(I)                                     CRS06860
ISN 0402              SY = XY(I)+XA*AI(6)+XC(2)+DPY(I)                                     CRS06870
ISN 0403              SZ = XZ(I)+XA*AI(9)+XC(3)+DPZ(I)                                     CRS06880
ISN 0404              SL = XL(I)+XC(4)+DPL(I)                                              CRS06890
ISN 0405              SM = XM(I)+XC(5)+DPM(I)                                              CRS06900
ISN 0406              SN = XN(I)+XC(6)+DPN(I)                                              CRS06910
                 C GET P,Q,R,U,V,W                                                         CRS06920
ISN 0407              PP = P(I)                                                            CRS06930
ISN 0408              QQ = Q(I)                                                            CRS06940
ISN 0409              RR = R(I)                                                            CRS06950
ISN 0410              UU = U(I)                                                            CRS06960
ISN 0411              VV = V(I)                                                            CRS06970
ISN 0412              WW = W(I)                                                            CRS06980
                 C MASS                                                                    CRS06990
ISN 0413              WGTI = 1.0/WGT(I)                                                    CRS07000
ISN 0414              ZM = 386.0*WGTI                                                      CRS07010
ISN 0415              XACC(I) = SX*WGTI                                                    CRS07020
ISN 0416              YACC(I) = SY*WGTI                                                    CRS07030
ISN 0417              ZACC(I) = SZ*WGTI                                                    CRS07040
                 C (25)                                                                    CRS07050
ISN 0418              UDOTI = UDOT(I)                                                      CRS07060
ISN 0419              UDOT(I) = SX*ZM-QQ*WW+RR*VV                                          CRS07070
```

Figure 108. (Continued)

```
ISN 0420          VDOTI = VDOT(I)                                                  CRS07080
ISN 0421          VDOT(I) = SY*ZM-RR*UU+PP*WW                                      CRS07090
ISN 0422          WDOTI = WDOT(I)                                                  CRS07100
ISN 0423          WDOT(I) = SZ*ZM-PP*VV+QQ*UU                                      CRS07110
            C (26)                                                                 CRS07120
ISN 0424          T1 = -XZI(I)*PP-YZI(I)*QQ+ZI(I)*RR+HEZ(I)                        CRS07130
ISN 0425          T2 = XI(I)*PP-XYI(I)*QQ-XZI(I)*RR+HEX(I)                         CRS07140
ISN 0426          T3 = -XYI(I)*PP+YI(I)*QQ-YZI(I)*RR+HEY(I)                        CRS07150
ISN 0427          SL = SL-QQ*T1+RR*T3                                              CRS07160
ISN 0428          SM = SM-RR*T2+PP*T1                                              CRS07170
ISN 0429          SN = SN-PP*T3+QQ*T2                                              CRS07180
            C (25)                                                                 CRS07190
ISN 0430          DEL = DELI(I)                                                    CRS07200
ISN 0431          PDOTI = PDOT(I)                                                  CRS07210
ISN 0432          PDOT(I) = DEL*(SL*XI1(I)+SM*XI2(I)+SN*XI3(I))                    CRS07220
ISN 0433          QDOTI = QDOT(I)                                                  CRS07230
ISN 0434          QDOT(I) = DEL*(SL*XI2(I)+SM*XI5(I)+SN*XI4(I))                    CRS07240
ISN 0435          RDOTI = RDOT(I)                                                  CRS07250
ISN 0436          RDOT(I) = DEL*(SL*XI3(I)+SM*XI4(I)+SN*XI6(I))                    CRS07260
ISN 0437          IF(TIME) 2000,2000,300                                           CRS07270
ISN 0438      300 U(I) = TT*U(I)+ET*(UOLD(I)+DTHALF*(UDOT(I)+UDOTI))               CRS07280
ISN 0439          V(I) = TT*V(I)+ET*(VOLD(I)+DTHALF*(VDOT(I)+VDOTI))               CRS07290
ISN 0440          W(I) = TT*W(I)+ET*(WOLD(I)+DTHALF*(WDOT(I)+WDOTI))               CRS07300
ISN 0441          P(I) = TT*P(I)+ET*(POLD(I)+DTHALF*(PDOT(I)+PDOTI))               CRS07310
ISN 0442          Q(I) = TT*Q(I)+ET*(QOLD(I)+DTHALF*(QDOT(I)+QDOTI))               CRS07320
ISN 0443          R(I) = TT*R(I)+ET*(ROLD(I)+DTHALF*(RDOT(I)+RDOTI))               CRS07330
ISN 0444          PIN(I) = TT*PIN(I)+ET*(PINO(I)+DTHALF*(P(I)+POLD(I)))            CRS07340
ISN 0445          QIN(I) = TT*QIN(I)+ET*(QINO(I)+DTHALF*(Q(I)+QOLD(I)))            CRS07350
ISN 0446          RIN(I) = TT*RIN(I)+ET*(RINO(I)+DTHALF*(R(I)+ROLD(I)))            CRS07360
ISN 0447          IF ((IPENSW(I).NE.0).OR.(I.EQ.INDP).OR.(INDP.EQ.0))  GO TO 2000  CRS07370
            C                                                                      CRS07380
            C        CONTROL VOLUME PENETRATION CALCULATIONS                       CRS07390
            C                                                                      CRS07400
ISN 0449          TP1=X(I)-X(INDP)                                                 CRS07410
ISN 0450          TP2=Y(I)-Y(INDP)                                                 CRS07420
ISN 0451          TP3=Z(I)-Z(INDP)                                                 CRS07430
ISN 0452          XP1=AP(1)*TP1+AP(2)*TP2+AP(3)*TP3                                CRS07440
ISN 0453          YP1=AP(4)*TP1+AP(5)*TP2+AP(6)*TP3                                CRS07450
ISN 0454          ZP1=AP(7)*TP1+AP(8)*TP2+AP(9)*TP3                                CRS07460
ISN 0455          IF ((-XNBAR.GT.XP1).OR.(XP1.GT.XPBAR))  GO TO 2000               CRS07470
ISN 0457          IF ((-YNBAR.GT.YP1).OR.(YP1.GT.YPBAR))  GO TO 2000               CRS07480
ISN 0459          IF ((-ZNBAR.GT.ZP1).OR.(ZP1.GT.ZPBAR))  GO TO 2000               CRS07490
ISN 0461          KPEN=KPEN+1                                                      CRS07500
ISN 0462          IPEN(KPEN)=I                                                     CRS07510
ISN 0463          TPEN(KPEN)=TIME                                                  CRS07520
ISN 0464          IPENSW(I)=1                                                      CRS07530
ISN 0465          PRINT 1080, I,TIME                                               CRS07540
ISN 0466     1080 FORMAT(1H0,' CONTROL VOLUME PENETRATED BY MASS ',I2,', TIME=',   CRS07550
                 1 F10.5)                                                          CRS07560
ISN 0467     2000 CONTINUE                                                         CRS07570
ISN 0468          RETURN                                                           CRS07580
ISN 0469          END                                                              CRS07590
```

Figure 108. (Continued)

```
LEVEL 20.1 (MAY 71)                     OS/360  FORTRAN H                          DATE  73.298/10.02.52

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                             SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
  ISN 0002            SUBROUTINE DUAIJ                                                     CRS07600
  ISN 0003            IMPLICIT REAL*8 (A-H,O-Z)                                            CRS07610
  ISN 0004            INTEGER*2      IDPLOT,N,ISP,      NN,IGS                             CRS07620
  ISN 0005            DIMENSION SINCOS(6),XIHOLD(9,2),XYZIJI(9),XYZIJJ(9),PROD(9),         CRS07630
                     1 XIIJ(3),XK3(6,6,60),CBAR(80)                                        CRS07640
  ISN 0006            COMMON/COMALL/ C(6,60),P(60),L(60),R(60),U(60),V(60),W(60),X(60),    CRS00160
                     1 Y(60),Z(60),AI(9),AJ(9),FM(2880),SC(60,3),XC(6),XK(2880),XI(60),    CRS00170
                     2 YI(60),ZI(60),XYI(60),XZI(60),YZI(60),AIJ(9),BIJ(540),DIJ(720),     CRS00180
                     3 DKI(60),CAI(540),VLE(480),WGT(60),PHI(60),THETA(60),PSI(60),        CRS00190
                     4 PDOT(60),QDOT(60),RDOT(60),UDOT(60),VDOT(60),WDOT(60),XDOT(60),     CRS00200
                     5 YDOT(60),ZDOT(60),PHIDOT(60),THEDOT(60),PSIDOT(60),TIME,DELTAT,     CRS00210
                     6 XACC(60),YACC(60),ZACC(60),AITAJ(9),AIDOT(9),FMBAR(2880),           CRS00220
                     7 PHIIJ(60),THEIJ(60),PSIIJ(60),SUMDF(6,80),TITLE(10),XBAR(60,3),     CRS00230
                     8 FSPHAR(60,3),VECDOT(3,3),DX(60),DY(60),DZ(60),DPIN(60),DRIN(60),    CRS00240
                     8 DQIN(60),SEIJ(60),DEIJ(80),CEIK(60,3),
                     9ZAR(700),PLOT(30000),IMPLOT(500),                                    CRS07740
                     ARM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(150),IG(60),JG(80),       CRS07750
                     6 N(460),NN(60,3),ISP(60,3),IJPK(60),IDPLOT(150)                      CRS00270
  ISN 0007            EQUIVALENCE (XIHOLD(1,1),XYZIJI(1)),(XIHOLD(1,2),XYZIJJ(1))          CRS07760
  ISN 0008            EQUIVALENCE (S1,SINCOS(1)),(C1,SINCOS(2)),(S2,SINCOS(3))             CRS07790
  ISN 0009            EQUIVALENCE (C2,SINCOS(4)),(S3,SINCOS(5)),(C3,SINCOS(6))             CRS07800
  ISN 0010            EQUIVALENCE (XK(1),XK3(1,1,1))                                       CRS07810
  ISN 0011            SIN(X) = DSIN(X)                                                     CRS07820
  ISN 0012            COS(X) = DCOS(X)                                                     CRS07830
  ISN 0013            SQRT(X) = DSQRT(X)                                                   CRS07840
  ISN 0014            ARSIN(X) = DARSIN(X)                                                 CRS07850
  ISN 0015            ATAN2(Y,X) = DATAN2(Y,X)                                             CRS07860
  ISN 0016            IOLD=0                                                               CRS07870
  ISN 0017            DO 1100 I = 1,NM                                                     CRS07880
  ISN 0018            ARG=PHI(I)                                                           CRS07890
  ISN 0019            S1=SIN(ARG)                                                          CRS07900
  ISN 0020            C1=COS(ARG)                                                          CRS07910
  ISN 0021            ARG=THETA(I)                                                         CRS07920
  ISN 0022            S2=SIN(ARG)                                                          CRS07930
  ISN 0023            C2=COS(ARG)                                                          CRS07940
  ISN 0024            ARG=PSI(I)                                                           CRS07950
  ISN 0025            S3=SIN(ARG)                                                          CRS07960
  ISN 0026            C3=COS(ARG)                                                          CRS07970
  ISN 0027            DO 1085 J = 1,6                                                      CRS07980
  ISN 0028            T=SINCOS(J)                                                          CRS07990
  ISN 0029            IF (T) 1070,1085,1075                                                CRS08000
```

Figure 108. (Continued)

PAGE 002

```
ISN 0030       1070 T=-T                                                CRS08010
ISN 0031       1075 IF(T-1.E-10) 1060,1085,1085                         CRS08020
ISN 0032       1060 SINCOS(J)=0.                                        CRS08030
ISN 0033       1085 CONTINUE                                            CRS08040
ISN 0034            J=9*(I-1)                                           CRS08050
               C MOVE AI'S TO OLD AI'S                                  CRS08060
ISN 0035            DO 1090 JJ = 1,9                                    CRS08070
ISN 0036       1090 OAI(J+JJ)=BIJ(J+JJ)                                 CRS08080
ISN 0037            S1S2=S1*S2                                          CRS08090
ISN 0038            C1S2=C1*S2                                          CRS08100
ISN 0039            BIJ(J+1)=C2*C3                                      CRS08110
ISN 0040            BIJ(J+2)=C2*S3                                      CRS08120
ISN 0041            BIJ(J+3)=-S2                                        CRS08130
ISN 0042            BIJ(J+4)=-C1*S3+S1S2*C3                             CRS08140
ISN 0043            BIJ(J+5)=C1*C3+S1S2*S3                              CRS08150
ISN 0044            BIJ(J+6)=S1*C2                                      CRS08160
ISN 0045            BIJ(J+7)=S1*S3+C1S2*C3                              CRS08170
ISN 0046            BIJ(J+8)=-S1*C3+C1S2*S3                             CRS08180
ISN 0047            BIJ(J+9)=C1*C2                                      CRS08190
ISN 0048       1100 CONTINUE                                            CRS08200
               C                                                        CRS08210
ISN 0049            DO 1010 IJ = 1,IGS                                  CRS08220
ISN 0050            S1 = SIN(PHIIJ(IJ))                                 CRS08230
ISN 0051            C1 = COS(PHIIJ(IJ))                                 CRS08240
ISN 0052            S2 = SIN(THEIJ(IJ))                                 CRS08250
ISN 0053            C2 = COS(THEIJ(IJ))                                 CRS08260
ISN 0054            S3 = SIN(PSIIJ(IJ))                                 CRS08270
ISN 0055            C3 = COS(PSIIJ(IJ))                                 CRS08280
ISN 0056            DO 1040 J = 1,6                                     CRS08290
ISN 0057            T = SINCOS(J)                                       CRS08300
ISN 0058            IF (T) 1045,1040,1050                               CRS08310
ISN 0059       1045 T = -T                                              CRS08320
ISN 0060       1050 IF(T-1.E-10) 1055,1040,1040                         CRS08330
ISN 0061       1055 SINCOS(J) = 0.0                                     CRS08340
ISN 0062       1040 CONTINUE                                            CRS08350
ISN 0063            AIJ(1) = C2*C3                                      CRS08360
ISN 0064            AIJ(2) = C2*S3                                      CRS08370
ISN 0065            AIJ(3) = -S2                                        CRS08380
ISN 0066            AIJ(4) = -C1*S3+S1*S2*C3                            CRS08390
ISN 0067            AIJ(5) = C1*C3+S1*S2*S3                             CRS08400
ISN 0068            AIJ(6) = S1*C2                                      CRS08410
ISN 0069            AIJ(7) = S1*S3+C1*S2*C3                             CRS08420
ISN 0070            AIJ(8) = -S1*C3+C1*S2*S3                            CRS08430
ISN 0071            AIJ(9) = C1*C2                                      CRS08440
ISN 0072            I = 9*(IJ-1)                                        CRS08450
ISN 0073            DO 1015 J = 1,9                                     CRS08460
ISN 0074       1015 DIJ(I+J) = AIJ(J)                                   CRS08470
ISN 0075            CBIJ = CBAR(IJ)                                     CRS08480
ISN 0076            I = IG(IJ)                                          CRS08490
ISN 0077            J = JG(IJ)                                          CRS08500
ISN 0078            IF ((IOLD.NE.0).AND.(I.EQ.IOLD))  GO TO 1120        CRS08510
ISN 0080            IS=9*(I-1)                                          CRS08520
ISN 0081            DO 1110 JJ = 1,9                                    CRS08530
ISN 0082            IS=IS+1                                             CRS08540
```

Figure 108. (Continued)

```
ISN 0083      1110 AI(JJ)=BIJ(IS)                                                      CRS08550
ISN 0084      1120 IULD=1                                                              CRS08560
ISN 0085           IS=9*(J-1)                                                          CRS08570
ISN 0086           DO 1125 JJ = 1,9                                                    CRS08580
ISN 0087           IS=IS+1                                                             CRS08590
ISN 0088      1125 AJ(JJ) = BIJ(IS)                                                    CRS08600
ISN 0089           AITAJ(1)=AI(1)*AJ(1)+AI(2)*AJ(2)+AI(3)*AJ(3)                        CRS08610
ISN 0090           AITAJ(2)=AI(4)*AJ(1)+AI(5)*AJ(2)+AI(6)*AJ(3)                        CRS08620
ISN 0091           AITAJ(3)=AI(7)*AJ(1)+AI(8)*AJ(2)+AI(9)*AJ(3)                        CRS08630
ISN 0092           AITAJ(4)=AI(1)*AJ(4)+AI(2)*AJ(5)+AI(3)*AJ(6)                        CRS08640
ISN 0093           AITAJ(5)=AI(4)*AJ(4)+AI(5)*AJ(5)+AI(6)*AJ(6)                        CRS08650
ISN 0094           AITAJ(6)=AI(7)*AJ(4)+AI(8)*AJ(5)+AI(9)*AJ(6)                        CRS08660
ISN 0095           AITAJ(7)=AI(1)*AJ(7)+AI(2)*AJ(8)+AI(3)*AJ(9)                        CRS08670
ISN 0096           AITAJ(8)=AI(4)*AJ(7)+AI(5)*AJ(8)+AI(6)*AJ(9)                        CRS08680
ISN 0097           AITAJ(9)=AI(7)*AJ(7)+AI(8)*AJ(8)+AI(9)*AJ(9)                        CRS08690
              C                                                                        CRS08700
              C COMPUTE DAMPING COEFFICIENT MATRIX C                                   CRS08710
ISN 0098           KKS=1                                                               CRS08720
ISN 0099           DO 1312 KS = 1,2                                                    CRS08730
ISN 0100           IF (KS.EQ.2)  KKS=J                                                 CRS08740
ISN 0102           XTHOLD(1,KS)=XI(KKS)                                                CRS08750
ISN 0103           XTHOLD(2,KS)=XYI(KKS)                                               CRS08760
ISN 0104           XTHOLD(3,KS)=XZI(KKS)                                               CRS08770
ISN 0105           XTHOLD(4,KS)=XYI(KKS)                                               CRS08780
ISN 0106           XTHOLD(5,KS)=YI(KKS)                                                CRS08790
ISN 0107           XTHOLD(6,KS)=YZI(KKS)                                               CRS08800
ISN 0108           XTHOLD(7,KS)=XZI(KKS)                                               CRS08810
ISN 0109           XTHOLD(8,KS)=YZI(KKS)                                               CRS08820
ISN 0110      1312 XTHOLD(9,KS)=ZI(KKS)                                                CRS08830
              C                                                                        CRS08840
ISN 0111           PROD(1)=AITAJ(1)*XYZIJJ(1)+AITAJ(4)*XYZIJJ(2)+AITAJ(7)*XYZIJJ(3)    CRS08850
ISN 0112           PROD(2)=AITAJ(2)*XYZIJJ(1)+AITAJ(5)*XYZIJJ(2)+AITAJ(8)*XYZIJJ(3)    CRS08860
ISN 0113           PROD(3)=AITAJ(3)*XYZIJJ(1)+AITAJ(6)*XYZIJJ(2)+AITAJ(9)*XYZIJJ(3)    CRS08870
ISN 0114           PROD(4)=AITAJ(1)*XYZIJJ(4)+AITAJ(4)*XYZIJJ(5)+AITAJ(7)*XYZIJJ(6)    CRS08880
ISN 0115           PROD(5)=AITAJ(2)*XYZIJJ(4)+AITAJ(5)*XYZIJJ(5)+AITAJ(8)*XYZIJJ(6)    CRS08890
ISN 0116           PROD(6)=AITAJ(3)*XYZIJJ(4)+AITAJ(6)*XYZIJJ(5)+AITAJ(9)*XYZIJJ(6)    CRS08900
ISN 0117           PROD(7)=AITAJ(1)*XYZIJJ(7)+AITAJ(4)*XYZIJJ(8)+AITAJ(7)*XYZIJJ(9)    CRS08910
ISN 0118           PROD(8)=AITAJ(2)*XYZIJJ(7)+AITAJ(5)*XYZIJJ(8)+AITAJ(8)*XYZIJJ(9)    CRS08920
ISN 0119           PROD(9)=AITAJ(3)*XYZIJJ(7)+AITAJ(6)*XYZIJJ(8)+AITAJ(9)*XYZIJJ(9)    CRS08930
              C                                                                        CRS08940
ISN 0120           XYZIJJ(1)=PROD(1)*AITAJ(1)+PROD(4)*AITAJ(4)+PROD(7)*AITAJ(7)        CRS08950
ISN 0121           XYZIJJ(2)=PROD(2)*AITAJ(1)+PROD(5)*AITAJ(4)+PROD(8)*AITAJ(7)        CRS08960
ISN 0122           XYZIJJ(3)=PROD(3)*AITAJ(1)+PROD(6)*AITAJ(4)+PROD(9)*AITAJ(7)        CRS08970
ISN 0123           XYZIJJ(4)=PROD(1)*AITAJ(2)+PROD(4)*AITAJ(5)+PROD(7)*AITAJ(8)        CRS08980
ISN 0124           XYZIJJ(5)=PROD(2)*AITAJ(2)+PROD(5)*AITAJ(5)+PROD(8)*AITAJ(8)        CRS08990
ISN 0125           XYZIJJ(6)=PROD(3)*AITAJ(2)+PROD(6)*AITAJ(5)+PROD(9)*AITAJ(8)        CRS09000
ISN 0126           XYZIJJ(7)=PROD(1)*AITAJ(3)+PROD(4)*AITAJ(6)+PROD(7)*AITAJ(9)        CRS09010
ISN 0127           XYZIJJ(8)=PROD(2)*AITAJ(3)+PROD(5)*AITAJ(6)+PROD(8)*AITAJ(9)        CRS09020
ISN 0128           XYZIJJ(9)=PROD(3)*AITAJ(3)+PROD(6)*AITAJ(6)+PROD(9)*AITAJ(9)        CRS09030
ISN 0129           DO 1314 KS = 1,9                                                    CRS09040
ISN 0130      1314 XYZIJI(KS)=XYZIJI(KS)+XYZIJJ(KS)                                    CRS09050
ISN 0131           PROD(1)=XYZIJI(1)*AIJ(1)+XYZIJI(4)*AIJ(2)+XYZIJI(7)*AIJ(3)          CRS09060
ISN 0132           PROD(2)=XYZIJI(2)*AIJ(1)+XYZIJI(5)*AIJ(2)+XYZIJI(8)*AIJ(3)          CRS09070
ISN 0133           PROD(3)=XYZIJI(3)*AIJ(1)+XYZIJI(6)*AIJ(2)+XYZIJI(9)*AIJ(3)          CRS09080
```

Figure 108. (Continued)

```
ISN 0134          PROD(4)=XYZIJI(1)*AIJ(4)+XYZIJI(4)*AIJ(5)+XYZIJI(7)*AIJ(6)         CRS09090
ISN 0135          PROD(5)=XYZIJI(2)*AIJ(4)+XYZIJI(5)*AIJ(5)+XYZIJI(8)*AIJ(6)         CRS09100
ISN 0136          PROD(6)=XYZIJI(3)*AIJ(4)+XYZIJI(6)*AIJ(5)+XYZIJI(9)*AIJ(6)         CRS09110
ISN 0137          PROD(7)=XYZIJI(1)*AIJ(7)+XYZIJI(4)*AIJ(8)+XYZIJI(7)*AIJ(9)         CRS09120
ISN 0138          PROD(8)=XYZIJI(2)*AIJ(7)+XYZIJI(5)*AIJ(8)+XYZIJI(8)*AIJ(9)         CRS09130
ISN 0139          PROD(9)=XYZIJI(3)*AIJ(7)+XYZIJI(6)*AIJ(8)+XYZIJI(9)*AIJ(9)         CRS09140
            C                                                                       CRS09150
ISN 0140          XIIJ(1)=AIJ(1)*PROD(1)+AIJ(2)*PROD(2)+AIJ(3)*PROD(3)               CRS09160
ISN 0141          XIIJ(2)=AIJ(4)*PROD(4)+AIJ(5)*PROD(5)+AIJ(6)*PROD(6)               CRS09170
ISN 0142          XIIJ(3)=AIJ(7)*PROD(7)+AIJ(8)*PROD(8)+AIJ(9)*PROD(9)               CRS09180
ISN 0143          DO 1020 K = 1,3                                                    CRS09190
ISN 0144     1020 C(K,IJ) = .101600*C6IJ*SQRT(XK3(K,K,IJ)*(WGT(I)+WGT(J)))           CRS09200
ISN 0145          DO 1030 K = 4,6                                                    CRS09210
ISN 0146     1030 C(K,IJ)=2.*C6IJ*SQRT(XK3(K,K,IJ)*XIIJ(K-3))                        CRS09220
ISN 0147     1010 CONTINUE                                                           CRS09230
ISN 0148          RETURN                                                             CRS09240
            C*********************************                                      CRS09250
            C*********************************                                      CRS09260
ISN 0149          ENTRY INPUT                                                        CRS09270
            C*********************************                                      CRS09280
            C*********************************                                      CRS09290
ISN 0150          REAL*8 LEAF,MU,KF                                                  CRS09300
ISN 0151          REAL*4 KR(15),SLOPE,XKS,XKI,XKR                                    CRS09310
ISN 0152          INTEGER*2 INBUF(80),II(81),KK(81),IR(81),JR(81),CHUG               CRS09320
ISN 0153          INTEGER*2 IO(81),JQ(81),LQ(81),NPG(81),NLSFLG,BLANK,IJPR           CRS09330
ISN 0154          DIMENSION XDP(60),YDP(60),ZDP(60),PHIDP(50),THEDP(60),PSIDP(60),   CRS09340
                 1 VMAX2(6,60)                                                       CRS09350
            C*****THE FOLLOWING ARE ALSO USED BY CFORCE                             CRS09360
ISN 0155          DIMENSION XMU(60,3),XKE(60,3),SI(60,3),SA(60,3),SH(60,3),          CRS09370
                 1 SF(60,3),FSPUI(60,3),FSPUF(60,3)                                  CRS09380
ISN 0156          COMMON/DERIN/ XNBAR,XFBAR,YNBAR,YPBAR,ZNBAR,ZPBAR                  CRS09385
ISN 0157          COMMON/DERIN/HEX(60),HEY(60),HEZ(60),ALIFT(60),VMAX(480),INDP      CRS09390
ISN 0158          COMMON/LINES/ XKS(1200),XKI(1200),XKR(1200),NLSFLG(480),CHUG(80)   CRS09400
ISN 0159          EQUIVALENCE (VMAX(1),VMAX2(1))                                     CRS09410
ISN 0160          DATA BLANK/'  '/                                                   CRS09420
ISN 0161          READ5100, TITLE                                                    CRS09430
ISN 0162     5100 FORMAT(10A8)                                                       CRS09440
ISN 0163          PRINT 5500, TITLE                                                  CRS09450
ISN 0164     5500 FORMAT(1H1,10A8)                                                   CRS09460
ISN 0165          READ5200,NM,IPRINT,DELTAT,TMAX                                     CRS09470
ISN 0166          PRINT 5501, NM,IPRINT,DELTAT,TMAX                                  CRS09480
ISN 0167     5501 FORMAT('OMASSES =',I3,' DP/DT =',I4,' DT =',F7.5,' TMAX =',F7.3)   CRS09490
ISN 0168          IF(DELTAT) 5017,5017,5018                                          CRS09500
ISN 0169     5017 NM = 0                                                             CRS09510
ISN 0170          GO TO 5000                                                         CRS09520
ISN 0171     5018 CONTINUE                                                           CRS09530
ISN 0172          IF(NM) 5000,5000,5016                                              CRS09540
ISN 0173     5200 FORMAT(2I3,2E12.0)                                                 CRS09550
ISN 0174     5016 READ5300, XGDOT,YGDOT,ZGDOT                                        CRS09560
ISN 0175          READ5300, PPR,QPR,RPR                                              CRS09570
ISN 0176          READ5300, PHIPR,THEPR,PSIPR,ZG                                     CRS09580
ISN 0177     5300 FORMAT(6E12.0)                                                     CRS09590
ISN 0178          PRINT 5502, XGDOT,YGDOT,ZGDOT                                      CRS09600
ISN 0179     5502 FORMAT('  XGDOT =',1PE13.5,'  YGDOT =',E13.5,'  ZGDOT =',E13.5)    CRS09610
```

Figure 108. (Continued)

```
ISN 0160            PRINT 5503, PPK,QPK,RPK                                              CRS09620
ISN 0161       5503 FORMAT(5X,'P'' =',1PE13.5,5X,'Q'' =',E13.5,5X,'R'' =',E13.5)         CRS09630
ISN 0162            PRINT 5504, PHIPR,THEPR,PSIPR,ZG                                     CRS09640
ISN 0163       5504 FORMAT('   PHI'' =',1PE13.5,' THETA'' =',E13.5,'   PSI'' =',E13.5,   CRS09650
                   1  5X,'ZG =',E13.5)                                                   CRS09660
              C READ WEIGHTS                                                             CRS09670
ISN 0164            READ5600, (WGT(I),I=1,NM)                                            CRS09680
ISN 0165            PRINT 5505                                                           CRS09690
ISN 0166       5505 FORMAT('0WEIGHTS')                                                   CRS09700
ISN 0167            PRINT 5506, (I,WGT(I),I=1,NM)                                        CRS09710
ISN 0168       5506 FORMAT(1H ,I3,1PE15.5)                                               CRS09720
              C READ MOMENTS AND INERTIA PRODUCTS                                        CRS09730
ISN 0169            READ5600, (XI(I),YI(I),ZI(I),XYI(I),YZI(I),XZI(I),I=1,NM)            CRS09740
ISN 0190            READ5700, (XDP(I),YDP(I),ZDP(I),I=1,NM)                              CRS09750
ISN 0191       5700 FORMAT(3E12.0)                                                       CRS09760
ISN 0192            PRINT 5507                                                           CRS09770
ISN 0193       5507 FORMAT('0I,IX(I),IY(I),IZ(I),IXY(I),IYZ(I),IXZ(I)')                  CRS09780
ISN 0194            PRINT 5508, (I,XI(I),YI(I),ZI(I),XYI(I),YZI(I),XZI(I),I=1,NM)        CRS09790
ISN 0195       5508 FORMAT(1H ,I5,1P6E15.5)                                              CRS09800
ISN 0196            PRINT 5509                                                           CRS09810
ISN 0197       5509 FORMAT('0I,X''''(I),Y''''(I),Z''''(I)')                              CRS09820
ISN 0198            PRINT 5510, (I,XDP(I),YDP(I),ZDP(I),I=1,NM)                          CRS09830
ISN 0199       5510 FORMAT(1H ,I3,1P3E15.5)                                              CRS09840
              C*****CLEAR SOME ARRAYS WHICH ARE SPARSE                                   CRS09850
ISN 0200            DO 5110 I = 1,NM                                                     CRS09860
ISN 0201            HEX(I) = 0.0                                                         CRS09870
ISN 0202            HEY(I) = 0.0                                                         CRS09880
ISN 0203            HEZ(I) = 0.0                                                         CRS09890
ISN 0204            PHIDP(I) = 0.0                                                       CRS09900
ISN 0205            THEDP(I) = 0.0                                                       CRS09910
ISN 0206            PSIDP(I) = 0.0                                                       CRS09920
ISN 0207       5110 ALIFT(I) = 0.0                                                       CRS09930
              C*****READ POINTERS TO NON-ZERO ANGULAR MOMENTUM CARDS                     CRS09940
ISN 0208            READ 5600, NI,(INBUF(I),I=1,NI)                                      CRS09950
ISN 0209            PRINT 5511, NI                                                       CRS09960
ISN 0210       5511 FORMAT('OTHERE ARE',I3,' I''S HAVING NON-ZERO HE OR ',               CRS09970
                   1 'PHI''''',THETA'''',PSI'''''')                                      CRS09980
ISN 0211            IF(NI.EQ.0) GO TO 5533                                               CRS09990
ISN 0213            PRINT 5512                                                           CRS10000
ISN 0214       5512 FORMAT('0I,HEX(I),HEY(I),HEZ(I),PHI''''(I),THETA''''(I),'            CRS10010
                   1 ,'PSI''''(I)')                                                      CRS10020
              C*****NOW READ NON-ZERO CARDS                                              CRS10030
ISN 0215            DO 5120 I = 1,NI                                                     CRS10040
ISN 0216            J = INBUF(I)                                                         CRS10050
ISN 0217            READ 5300, HEX(J),HEY(J),HEZ(J),PHIDP(J),THEDP(J),PSIDP(J)           CRS10060
ISN 0218       5120 PRINT 5508, J,HEX(J),HEY(J),HEZ(J),PHIDP(J),THEDP(J),PSIDP(J)        CRS10070
              C*****READ POINTERS TO NON-ZERO AERODYNAMIC LIFTS                          CRS10080
ISN 0219       5533 READ 5600, NI,(INBUF(I),I=1,NI)                                      CRS10090
ISN 0220       5600 FORMAT(38I2)                                                         CRS10100
ISN 0221            PRINT 5513, NI                                                       CRS10110
ISN 0222       5513 FORMAT('OTHERE ARE',I3,' I''S HAVING NON-ZERO LC''S')                CRS10120
ISN 0223            IF(NI.EQ.0) GO TO 5534                                               CRS10130
              C*****READ NON-ZERO LIFTS                                                  CRS10140
ISN 0225            READ 5600, (ALIFT(INBUF(I)),I=1,NI)                                  CRS10150
```

Figure 108. (Continued)

```
ISN 0226      5600 FORMAT(E12.0)                                               CRS10160
ISN 0227           PRINT 5514                                                  CRS10170
ISN 0228      5514 FORMAT('0I,LC(I)')                                          CRS10180
ISN 0229           PRINT 5506, (INBUF(I),ALIFT(INBUF(I)),I=1,NI)               CRS10190
              C*****CLEAR EXTERNAL SPRING FLAGS (AND THE ASSOCIATED DATA ALTHO THIS  CRS10200
              C SHOULD NOT BE NECESSARY BECAUSE WE ONLY USE IT IF THE FLAG IS 1.    CRS10210
              C HOWEVER, THEY MUST BE CLEARED FOR THE SEARCH WHICH PRINTS THE INPUT.) CRS10220
ISN 0230      5534 DO 5130 K = 1,3                                             CRS10230
ISN 0231           DO 5130 I = 1,NN                                            CRS10240
ISN 0232           ISP(I,K) = 0                                                CRS10250
ISN 0233           XLBAR(I,K) = 0.0                                            CRS10260
ISN 0234           XMU(I,K) = 0.0                                              CRS10270
ISN 0235           XKE(I,K) = 0.0                                              CRS10280
ISN 0236           SI(I,K) = 0.0                                               CRS10290
ISN 0237           SA(I,K) = 0.0                                               CRS10300
ISN 0238           SB(I,K) = 0.0                                               CRS10310
ISN 0239           SF(I,K) = 0.0                                               CRS10320
ISN 0240           FSPOI(I,K) = 0.0                                            CRS10330
ISN 0241      5130 FSPOF(I,K) = 0.0                                            CRS10340
              C*****READ THE SPRING STUFF AND STORE IT.                        CRS10350
ISN 0242           IKCT = 1                                                    CRS10360
ISN 0243           PRINT 5515                                                  CRS10370
ISN 0244      5515 FORMAT('0I,K,LBAR(I,K),MU(I,K),KE(I,K)')                    CRS10380
ISN 0245      5140 READ 5810, II(IKCT),KK(IKCT),LBAR,MU,KE                     CRS10390
ISN 0246      5810 FORMAT(2I3,6X,3E12.0)                                       CRS10400
ISN 0247           I = II(IKCT)                                                CRS10410
ISN 0248           IF(I.EQ.0) GO TO 5150                                       CRS10420
ISN 0250           K = KK(IKCT)                                                CRS10430
ISN 0251           ISP(I,K) = 1                                                CRS10440
ISN 0252           XLBAR(I,K) = LBAR                                           CRS10450
ISN 0253           XMU(I,K) = MU                                               CRS10460
ISN 0254           XKE(I,K) = KE                                               CRS10470
ISN 0255           PRINT  5516, I,K,LBAR,MU,KE                                 CRS10480
ISN 0256      5516 FORMAT(1H ,2I3,1P3E15.5)                                    CRS10490
ISN 0257           IKCT = IKCT+1                                               CRS10500
ISN 0258           GO TO 5140                                                  CRS10510
ISN 0259      5150 IKCT = IKCT-1                                               CRS10520
ISN 0260           IF(IKCT.EQ.0) GO TO 5535                                    CRS10530
ISN 0262           PRINT 5517                                                  CRS10540
ISN 0263      5517 FORMAT('0I,K,SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPOI(I,K),',  CRS10550
                  1 'FSPOF(I,K)')                                              CRS10560
              C*****READ SI,SA,SB,SF,FSPOI,FSPOF                               CRS10570
ISN 0264           DO 5160 J = 1,IKCT                                          CRS10580
ISN 0265           I = II(J)                                                   CRS10590
ISN 0266           K = KK(J)                                                   CRS10600
ISN 0267           READ 5300, SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPOI(I,K),FSPOF(I,K)  CRS10610
ISN 0268      5160 PRINT 5518, I,K,SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPOI(I,K), CRS10620
                  1 FSPOF(I,K)                                                 CRS10630
ISN 0269      5518 FORMAT(1H ,2I3,1P6E15.5)                                    CRS10640
ISN 0270      5535 IGS = 0                                                     CRS10650
ISN 0271           PRINT 5519                                                  CRS10660
ISN 0272      5519 FORMAT('0IJ,I,J,PHI(I,J),THETA(I,J),PSI(I,J) (INTERNAL BEAMS)') CRS10670
              C READ THE I,J,PHIIJ,THEIJ,PSIIJ                                 CRS10680
ISN 0273      5015 READ5400, I,J,PHIIN,THEIN,PSIIN                             CRS10690
```

Figure 108. (Continued)

```
ISN 0274      5400 FORMAT(I3,3E12.0)                                          CRS10700
ISN 0275           IF(I) 5051,5051,5020                                       CRS10710
ISN 0276      5020 IGS = IGS+1                                                CRS10720
ISN 0277           IG(IGS) = I                                                CRS10730
ISN 0278           JG(IGS) = J                                                CRS10740
ISN 0279           PHIIJ(IGS) = PHIIN                                         CRS10750
ISN 0280           THEIJ(IGS) = THEIN                                         CRS10760
ISN 0281           PSIIJ(IGS) = PSIIN                                         CRS10770
ISN 0282           PRINT 5539, IGS,I,J,PHIIN,THEIN,PSIIN                      CRS10780
ISN 0283      5539 FORMAT(1H ,3I3,1P6E15.5)                                   CRS10785
ISN 0284           GO TO 5015                                                 CRS10790
          C*****THESE K-MATRICES ARE STORED BY ROW, THUS THE THE L,K          CRS10800
ISN 0285      5051 READ(5,10,(((XK3(L,K,IJ),L=1,6),K=1,6),IJ=1,IGS)           CRS10810
ISN 0286           PRINT 5520                                                 CRS10820
ISN 0287      5520 FORMAT('0I,J,K-MATRIX FOR INTERNAL BEAM I,J')              CRS10830
ISN 0288           DO 5521 IJ = 1,IGS                                         CRS10840
ISN 0289           PRINT 5510, IG(IJ),JG(IJ)                                  CRS10850
ISN 0290      5521 PRINT 5522, ((XK3(L,K,IJ),L=1,6),K=1,6)                    CRS10860
ISN 0291      5522 FORMAT(1H ,1P6E15.5)                                       CRS10870
ISN 0292           READ 5600, (CBAR(IJ),IJ=1,IGS)                             CRS10880
ISN 0293           PRINT 5523                                                 CRS10890
ISN 0294      5523 FORMAT('0IJ,I,J,CBAR(I,J)')                                CRS10900
ISN 0295           PRINT 5524, (IJ,IG(IJ),JG(IJ),CBAR(IJ),IJ=1,IGS)           CRS10910
ISN 0296      5524 FORMAT(1H ,3I3,1PE15.5)                                    CRS10920
          C*******KR TABLE INPUT                                              CRS10930
          C IN DERIV, TO SEE IF THERE IS A TABLE FOR A PARTICULAR IJL, WE LOOK  CRS10940
          C AT NLSFLG(IJL) AND IF IT IS NON-ZERO, IT WILL BE THE TABLE NUMBER  CRS10950
          C FOR THAT IJL.  WE STILL USE SLOPES AND INTERCEPTS FOR THE         CRS10960
          C INTERPOLATION BUT WE MUST FIND WHICH INTERVAL IN X WE'RE IN.      CRS10970
          C THIS IS DONE BY KEEPING, FOR EACH TABLE, A POINTER TO THE LOWER X OF  CRS10980
          C THE INTERVAL WE WERE IN AT THE LAST INTEGRATION STEP              CRS10990
          C (INTEGER*2 CHUG(KC)) ON THE GROUNDS THAT WE'RE PROBABLY           CRS11000
          C STILL IN THAT INTERVAL.  IF WE'RE NOT IN THAT INTERVAL, WE CHECK  CRS11010
          C ONE BY ONE IN THE APPROPRIATE DIRECTION UNTIL WE FIND THE RIGHT   CRS11020
          C INTERVAL AND WE SAVE THAT IN CHUG AND DO THE INTERPOLATION.       CRS11030
          C X(1) AND X(NPO) FOR EACH TABLE ARE REPLACED BY VERY LARGE (1E35)  CRS11040
          C NEGATIVE AND POSITIVE NUMBERS SO THAT WE NEED NEVER CHECK FOR BEING  CRS11050
          C OUT OF THE TABLE AND ALSO SO WE DON'T EVEN HAVE TO KNOW HOW MANY  CRS11060
          C POINTS IN THE TABLE.  (IF AN ARGUMENT EXCEEDS 1.E35 WE'LL BOMB    CRS11070
          C SOONER OR LATER). THIS ALLOWS VERY RAPID TABLE SEARCH AND         CRS11080
          C INTERPOLATION.                                                    CRS11090
          C*****CLEAR I,J,L NONLINEAR STIFFNESS FLAGS                         CRS11100
ISN 0297           DO 5010 I = 1,400                                          CRS11110
ISN 0298      5010 NLSFLG(I) = 0                                              CRS11120
          C*****INPUT KR TABLE SPECS                                          CRS11130
ISN 0299           NO = 0                                                     CRS11140
          C*****GO TO # OF TABLES ALLOWED + 1*****C                           CRS11145
ISN 0300           DO 5090 I = 1,E1                                           CRS11150
ISN 0301           READ5900, IO(I),JO(I),LO(I),NPO(I)                         CRS11160
ISN 0302      5900 FORMAT(4I3)                                                CRS11170
ISN 0303           IF(IO(I).EQ.0) GO TO 5050                                  CRS11180
ISN 0305           NO = I                                                     CRS11190
          C*****HUNT FOR I,J PAIR SO WE CAN STORE NO IN NLSFLG                CRS11200
ISN 0306           DO 5030 J = 1,IGS                                          CRS11210
```

Figure 108. (Continued)

```
ISN 0307          IF(IG(I).EQ.IG(J).AND.JG(I).EQ.JG(J)) GO TO 5040          CRS11220
ISN 0309     5030 CONTINUE                                                      CRS11230
           C*****NO SUCH I,J PAIR, ABORT                                        CRS11240
ISN 0310          PRINT5910, IO(I),JO(I)                                        CRS11250
ISN 0311          STOP                                                          CRS11260
ISN 0312     5910 FORMAT(1H1,'NON-EXISTENT I,J PAIR IN KR TABLE SPECS',2I5)     CRS11270
           C*****FOUND IT                                                       CRS11280
ISN 0313     5040 NLSFLG(6*(J-1)+LO(I)) = NO                                    CRS11290
ISN 0314     5090 CONTINUE                                                      CRS11300
           C*****TOO MANY KR TABLES, ABORT                                      CRS11310
ISN 0315          PRINT5920                                                     CRS11320
ISN 0316          STOP                                                          CRS11330
ISN 0317     5920 FORMAT(1H1,'TOO MANY KR TABLES')                              CRS11340
           C*****PRINT KR TABLE SPECS                                           CRS11350
ISN 0318     5050 IF(NO.EQ.0) GO TO 5536                                        CRS11360
ISN 0320          PRINT 5930                                                    CRS11370
ISN 0321     5930 FORMAT('CKR TABLE SPECS, I,J,L,NP')                           CRS11380
ISN 0322          PRINT5940,(IO(I),JO(I),LO(I),NPO(I),I=1,NO)                   CRS11390
ISN 0323     5940 FORMAT(1H ,4I5)                                               CRS11400
           C*****LOOP TO READ IN A TABLE                                        CRS11410
ISN 0324          K = -14                                                       CRS11420
ISN 0325          DO 5070 I = 1,NO                                              CRS11430
ISN 0326          NP = NPO(I)                                                   CRS11440
ISN 0327          IF(NP.LE.15) GO TO 5055                                       CRS11450
           C*****TOO MANY POINTS IN KR TABLE, ABORT                             CRS11460
ISN 0329          PRINT 5980, NP,I                                              CRS11470
ISN 0330          STOP                                                          CRS11480
ISN 0331     5980 FORMAT(1H1,I5,' POINTS IN KR TABLE',I3,' (MAX IS 15)')        CRS11490
           C*****SET CHUG TO 1,16,31,...                                        CRS11500
ISN 0332     5055 K = K+15                                                      CRS11510
ISN 0333          CHUG(I) = K                                                   CRS11520
ISN 0334          ICH = CHUG(I)-1                                               CRS11530
ISN 0335          READ5950, (XKR(ICH+J),KR(J),J=1,NP)                           CRS11540
ISN 0336     5950 FORMAT(2E12.0)                                                CRS11550
           C*****PRINT TABLE                                                    CRS11560
ISN 0337          PRINT5960,IO(I),JO(I),LO(I)                                   CRS11570
ISN 0338     5960 FORMAT(1H0,'KR TABLE FOR I,J,L =',3I5)                        CRS11580
ISN 0339          PRINT5970, (J,XKR(ICH+J),KR(J),J=1,NP)                        CRS11590
ISN 0340     5970 FORMAT(1H ,I3,1P,E15.5)                                       CRS11600
           C*****COMPUTE SLOPES AND INTERCEPTS                                  CRS11610
ISN 0341          NPM1 = NP-1                                                   CRS11620
ISN 0342          DO 5080 J = 1,NPM1                                            CRS11630
ISN 0343          SLOPE = (KR(J)- KR(J+1))/(XKR(ICH+J)-XKR(ICH+J+1))            CRS11640
ISN 0344          XKS(ICH+J) = SLOPE                                            CRS11650
ISN 0345     5080 XKI(ICH+J) = KR(J)-SLOPE*XKR(ICH+J)                           CRS11660
           C*****MOVE ENDPOINTS WAY OUT                                         CRS11670
ISN 0346          XKR(ICH+1) = -1.E35                                           CRS11680
ISN 0347          XKR(ICH+NP) = 1.E35                                           CRS11690
ISN 0348     5070 CONTINUE                                                      CRS11700
           C*****STANDARD VMAX = 100                                            CRS11710
ISN 0349     5536 DO 5180 I = 1,460                                             CRS11720
ISN 0350     5180 VMAX(I) = 100.0                                               CRS11730
ISN 0351          PRINT 5525                                                    CRS11740
ISN 0352     5525 FORMAT('0IJ,I,J,VMAX(I,J,1-6)')                               CRS11750
```

Figure 108. (Continued)

```
ISN 0353              IJCT = 0
ISN 0354         5170 IJCT = IJCT+1                                          CRS11760
ISN 0355              READ 5820, IR(IJCT),JR(IJCT)                           CRS11770
ISN 0356         5820 FORMAT(2I3)                                            CRS11780
ISN 0357              IF(IR(IJCT).NE.0) GO TO 5170                           CRS11790
ISN 0359              IJCT = IJCT-1                                          CRS11800
              C*****READ NON-STANDARD MAXIMUM DEFLECTIONS                    CRS11810
ISN 0360              IF(IJCT.EQ.0) GO TO 5537                               CRS11820
ISN 0362              DO 5190 K = 1,IJCT                                     CRS11830
ISN 0363              I = IR(K)                                              CRS11840
ISN 0364              J = JR(K)                                              CRS11850
              C*****HUNT FOR I,J PAIR (MUST HUNT)                            CRS11860
ISN 0365              DO 5210 L = 1,IGS                                      CRS11870
ISN 0366              IF(I.EQ.IG(L).AND.J.EQ.JG(L)) GO TO 5220               CRS11880
ISN 0368         5210 CONTINUE                                               CRS11890
              C*****NO SUCH PAIR, ABORT                                      CRS11900
ISN 0369              PRINT 5830, K,I,J                                      CRS11910
ISN 0370              STOP                                                   CRS11920
ISN 0371         5830 FORMAT(1H1,I3,'TH I,J PAIR(',2I3,') FOR VMAX DOES NOT EXIST.')  CRS11930
              C*****FOUND IT, READ A VMAX CARD                               CRS11940
ISN 0372         5220 READ 5300, (VMAX2(M,L),M=1,6)                          CRS11950
ISN 0373              PRINT 5539, (L,I,J,(VMAX2(M,L),M=1,6))                 CRS11960
ISN 0374         5190 CONTINUE                                               CRS11970
              C*****PRINT PLOT INDICATOR TITLES                              CRS11980
ISN 0375         5537 PRINT 5529                                             CRS11990
ISN 0376         5529 FORMAT(1H0,26X,'PLOT CARDS WHICH ARE NOT ALL BLANK',/) CRS12000
ISN 0377              PRINT 5526                                             CRS12010
ISN 0378         5526 FORMAT(13X,'1',9X,'2',9X,'3',9X,'4',9X,'5',9X,'6',9X,'7',9X,'8')  CRS12020
ISN 0379              PRINT 5527                                             CRS12030
ISN 0380         5527 FORMAT(4X,'1234567890123456789012345678901234567890123456789012345678901234567890',  CRS12040
                    1 '1234567890123456789012345678890',/)                   CRS12050
              C READ PLOT INDICATORS                                         CRS12060
ISN 0381              NPLOT = 0                                              CRS12070
ISN 0382              JM = KM                                                CRS12080
ISN 0383              DO 5035 I = 1,..                                       CRS12090
ISN 0384              IF(I.EQ.13) JM = IGS                                   CRS12100
ISN 0386              READ5926, INBUF                                        CRS12110
ISN 0387         5926 FORMAT(80A1)                                           CRS12120
ISN 0388              IANY = 0                                               CRS12130
ISN 0389              DO 5045 J = 1,JM                                       CRS12140
ISN 0390              IF (NPLOT.EQ.150)  GO TO 5035                          CRS12150
ISN 0392              IF(INBUF(J).EQ.BLANK) GO TO 5045                       CRS12160
ISN 0394              IANY = 1                                               CRS12170
ISN 0395              NPLOT = NPLOT+1                                        CRS12180
ISN 0396              IDPLOT(NPLOT) = I                                      CRS12190
ISN 0397              IPLOT(NPLOT) = J                                       CRS12200
ISN 0398         5045 CONTINUE                                               CRS12210
ISN 0399              IF(IANY.EQ.0) GO TO 5035                               CRS12220
              C*****GOT SOME I'S IN THIS CARD SO PRINT IT.                   CRS12230
ISN 0401              PRINT 5528, I,INBUF                                    CRS12240
ISN 0402         5528 FORMAT(I3,1X,80A1)                                     CRS12250
ISN 0403         5035 CONTINUE                                               CRS12260
ISN 0404              READ5800,INDP                                          CRS12270
ISN 0405              PRINT 5538, INDP                                       CRS12280
                                                                             CRS12290
```

Figure 108. (Continued)

```
ISN 0406     5538 FORMAT('OINDP =',I3)
ISN 0407          IF (INDP.EQ.0)  GO TO 5065                                    CRS12300
ISN 0409          READ(5310, XNBAR,XPBAR,YNBAR,YPBAR,ZNBAR,ZPBAR                CRS12310
ISN 0410          PRINT 5530                                                    CRS12320
ISN 0411     5530 FORMAT('UXN-,XP-,YN-,YP-,ZN-,ZP-',/)                          CRS12330
ISN 0412          PRINT 5522, XNBAR,XPBAR,YNBAR,YPBAR,ZNBAR,ZPBAR               CRS12340
ISN 0413     5065 READ 5928, IJPR                                               CRS12350
ISN 0414          PRINT 5531                                                    CRS12360
ISN 0415     5531 FORMAT(1H0,34X,'URI(IJ) INDICATORS',/)                        CRS12370
ISN 0416          PRINT 5526                                                    CRS12380
ISN 0417          PRINT 5527                                                    CRS12390
ISN 0418          PRINT 5532, IJPR                                              CRS12400
ISN 0419     5532 FORMAT(4X,8GA1)                                               CRS12410
        C IF WE KNOW HOW MANY PLOTS WE WANT, WE CAN FIGURE OUT HOW MANY POINTS  CRS12420
        C PER PLOT WE CAN HAVE, ALTHO WE DON'T WANT MORE THAN 500, BECAUSE      CRS12430
        C WE COULDN'T NOTICE THE RESOLUTION ANYWAY.THE REST OF THIS FIGURES     CRS12440
        C OUT HOW OFTEN TO SAVE. A TRUNCATED ITPLOT WILL TRY TO SAVE TOO MUCH   CRS12450
        C AND THEN WE WOULDN'T GET TO TMAX, BUT IF WE WOULD ALMOST GET THERE    CRS12460
        C IT WILL NOT BE NOTICEABLE ON THE PLOT.                                CRS12470
ISN 0420          IF (NPLOT.EQ.0)  GO TO 5060                                   CRS12480
ISN 0422          IP = 50000/NPLOT                                              CRS12490
ISN 0423          IF(IP.GT.500) IP = 500                                        CRS12500
ISN 0425          FITER = TMAX/DELTAT+2.0                                       CRS12510
ISN 0426          ITPLOT = FITER/IP                                             CRS12520
ISN 0427          IF(ITPLOT.EQ.0) ITPLOT = 1                                    CRS12530
ISN 0429          IF(FITER/(IP*ITPLOT).GT.1.002) ITPLOT = ITPLOT+1              CRS12540
ISN 0431     5060 CONTINUE                                                      CRS12550
ISN 0432     5000 RETURN                                                        CRS12560
        C*********************************                                     CRS12570
        C*********************************                                     CRS12580
ISN 0433          ENTRY CFORCE                                                  CRS12590
        C*********************************                                     CRS12600
        C*********************************                                     CRS12610
ISN 0434          DIMENSION VA(3),VADOT(3),PBAR(3),XLNGTH(3),IISP(3),XXLBAR(3), CRS12620
                 1 FSP(3,3),XVDC(3,3),C4(3),C5(3),VC3(3),S(3),SDOT(3),PL(3,3)   CRS12630
ISN 0435          DIMENSION DPCRIN(4),DXYZ(3),DXYZPR(3),TERM(6)                 CRS12640
ISN 0436          COMMON/MAINCF/TMAX,IPRINT,ITPLOT,IHS(60,3)
ISN 0437          EQUIVALENCE (C4(1),DXYZ(1)),(C5(1),DXYZPR(1))                 CRS12650
ISN 0438          VA(1) = X(I)
ISN 0439          VA(2) = Y(I)                                                  CRS12660
ISN 0440          VA(3) = Z(I)                                                  CRS12670
ISN 0441          VADOT(1) = XDOT(I)                                            CRS12680
ISN 0442          VADOT(2) = YDOT(I)                                            CRS12690
ISN 0443          VADOT(3) = ZDOT(I)                                            CRS12700
ISN 0444          PBAR(1) = P(I)                                                CRS12710
ISN 0445          PBAR(2) = Q(I)                                                CRS12720
ISN 0446          PBAR(3) = R(I)                                                CRS12730
        C INITIALIZE SOME MORE                                                  CRS12740
ISN 0447          DO 910 K = 1,3                                                CRS12750
ISN 0448          XLNGTH(K) = 0.0                                               CRS12760
ISN 0449          IISP(K) = ISP(I,K)                                            CRS12770
ISN 0450          XXLBAR(K) = XLBAR(I,K)                                        CRS12780
ISN 0451          DO 915 JJ = 1,3                                               CRS12790
ISN 0452          FSP(JJ,K) = 0.0                                               CRS12800
                                                                                CRS12810
```

Figure 108. (Continued)

```
ISN 0453      915 XVOC(JJ,K) = 0.0                                  CRS12820
ISN 0454      910 CONTINUE                                          CRS12830
            C LOOP G                                                CRS12840
ISN 0455          DO 920 K = 1,3                                    CRS12850
ISN 0456          IF (IISP(K)) 925,920,925                          CRS12860
ISN 0457      925 ISUB = 3*K                                        CRS12870
ISN 0458          DVC = AI(ISUB)*XXLBAR(K)                          CRS12880
ISN 0459          DVCDOT = AIDOT(ISUB)*XXLBAR(K)                    CRS12890
ISN 0460          VC = VA(3)+DVC                                    CRS12900
ISN 0461          VCDOT = VADOT(3)+DVCDOT                           CRS12910
ISN 0462          C4(K) = VC/DVC                                    CRS12920
ISN 0463          C5(K) = (DVC*VCDOT-VC*DVCDOT)/(DVC*DVC)           CRS12930
ISN 0464          VC3(K) = VC                                       CRS12940
ISN 0465      920 CONTINUE                                          CRS12950
            C LOOP H                                                CRS12960
ISN 0466          DO 30 K = 1,3                                     CRS12970
ISN 0467          IF(IISP(K)) 35,30,35                              CRS12980
ISN 0468       35 IF(VC3(K)) 30,30,40                               CRS12990
ISN 0469       40 ISUB = 3*(K-1)                                    CRS13000
ISN 0470          BARL = XXLBAR(K)                                  CRS13010
ISN 0471          SUM = 0.0                                         CRS13020
ISN 0472          SUMD = 0.0                                        CRS13030
            C LOOP J                                                CRS13040
ISN 0473          DO 50 J = 1,3                                     CRS13050
ISN 0474          ISUB = ISUB+1                                     CRS13060
ISN 0475          DVC = AI(ISUB)*BARL                               CRS13070
ISN 0476          DVCDOT = AIDOT(ISUB)*BARL                         CRS13080
ISN 0477          DVP = C4(K)*DVC                                   CRS13090
ISN 0478          DDP = C4(K)*DVCDOT+C5(K)*DVC                      CRS13100
ISN 0479          SUM = SUM+DVP*DVP                                 CRS13110
ISN 0480          SUMD = SUMD+DVP*DDP                               CRS13120
ISN 0481       50 CONTINUE                                          CRS13130
ISN 0482          SK = SQRT(SUM)                                    CRS13140
ISN 0483          S(K) = SK                                         CRS13150
ISN 0484          SC(I,K) = SK                                      CRS13160
ISN 0485          SDOT(K) = SUMD/SK                                 CRS13170
            C GET LENGTH                                            CRS13180
ISN 0486          IF(BARL) 55,60,60                                 CRS13190
ISN 0487       55 T = -BARL-SK                                      CRS13200
ISN 0488          IF(T) 65,65,70                                    CRS13210
ISN 0489       70 T = -1                                            CRS13220
ISN 0490          GO TO 65                                          CRS13230
ISN 0491       60 T = BARL-SK                                       CRS13240
ISN 0492          IF(T) 70,65,65                                    CRS13250
ISN 0493       65 XLNGTH(K) = T                                     CRS13260
ISN 0494       30 CONTINUE                                          CRS13270
ISN 0495          PL(1,1) = -SDOT(1)                                CRS13280
ISN 0496          PL(2,2) = -SDOT(2)                                CRS13290
ISN 0497          PL(3,3) = -SDOT(3)                                CRS13300
ISN 0498          PL(2,1) = PBAR(3)*XLNGTH(1)                       CRS13310
ISN 0499          PL(3,1) = -PBAR(2)*XLNGTH(1)                      CRS13320
ISN 0500          PL(1,2) = -PBAR(3)*XLNGTH(2)                      CRS13330
ISN 0501          PL(3,2) = PBAR(1)*XLNGTH(2)                       CRS13340
ISN 0502          PL(1,3) = PBAR(2)*XLNGTH(3)                       CRS13350
```

Figure 108. (Continued)

```
ISN 0503          PL(2,3) = -PBAR(I)*XLNGTH(3)                            CRS13360
              C LOOP K                                                    CRS13370
ISN 0504          DO 75 JJ = 1,3                                          CRS13380
ISN 0505          ISUB = JJ-3                                             CRS13390
ISN 0506          VAD = VADOT(JJ)                                         CRS13400
              C LOOP L                                                    CRS13410
ISN 0507          DO 80 K = 1,3                                           CRS13420
ISN 0508          IF(IISP(K)) 85,80,85                                    CRS13430
ISN 0509       85 IF(VC3(K)) 80,80,90                                     CRS13440
ISN 0510       90 SUM = 0.0                                               CRS13450
              C LOOP M                                                    CRS13460
ISN 0511          DO 95 L = 1,3                                           CRS13470
ISN 0512          ISUB = ISUB+3                                           CRS13480
ISN 0513       95 SUM = SUM+AI(ISUB)*PL(L,K)                              CRS13490
ISN 0514          VFEDOT(JJ,K) = VAD+SUM                                  CRS13500
ISN 0515       80 CONTINUE                                                CRS13510
ISN 0516       75 CONTINUE                                                CRS13520
              C LOOP N                                                    CRS13530
ISN 0517          DO 105 K = 1,3                                          CRS13540
ISN 0518          IF(IISP(K)) 110,105,110                                 CRS13550
ISN 0519      110 IF(VC3(K)) 105,105,115                                  CRS13560
ISN 0520      115 SK = S(K)                                               CRS13570
ISN 0521          SDIF = SK-SF(I,K)                                       CRS13580
ISN 0522          IF(SDIF) 120,120,125                                    CRS13590
ISN 0523      120 IF(IBS(I,K)) 130,130,135                                CRS13600
ISN 0524      125 IBS(I,K) = 1                                            CRS13610
ISN 0525      135 FSPU = FSPOF(I,K)+XKE(I,K)*SDIF                         CRS13620
ISN 0526          IF(FSPU) 140,190,190                                    CRS13630
ISN 0527      140 FSPU = 0.0                                              CRS13640
ISN 0528          GO TO 190                                               CRS13650
ISN 0529      130 SP = SK-FSPBAR(I,K)                                     CRS13660
              C FSPBAR = SHAR-FSPOBAR/KE                                  CRS13670
ISN 0530          IF(SP) 150,155,155                                      CRS13680
ISN 0531      150 FSPU = 0.0                                              CRS13690
ISN 0532          GO TO 160                                               CRS13700
              C   COMPUTE FSPO PER NEW EXTERNAL SPRING LOAD-STROKE CURVES 7/25/72 CRS13710
ISN 0533      155 FSPU=FSPUF(I,K)                                         CRS13720
ISN 0534          IF (SP.GE.SR(I,K))  GO TO 160                           CRS13730
ISN 0536          IF (SP.GT.SA(I,K))  GO TO 157                           CRS13740
ISN 0538          FSPU=FSPUI(I,K)                                         CRS13750
ISN 0539          IF (SP.GE.SI(I,K))  GO TO 160                           CRS13760
ISN 0541          FSPU=FSPU*SP/SI(I,K)                                    CRS13770
ISN 0542          GO TO 160                                               CRS13780
ISN 0543      157 FSPO=FSPUI(I,K)+(SP-SA(I,K))*(FSPO-FSPOI(I,K))/(SB(I,K)-SA(I,K))  CRS13790
ISN 0544      160 IF(SDOT(K)) 165,165,170                                 CRS13800
ISN 0545      170 NN(I,K) = 0                                             CRS13810
ISN 0546          GO TO 190                                               CRS13820
ISN 0547      165 IF(NN(I,K)) 190,175,190                                 CRS13830
ISN 0548      175 NN(I,K) = 1                                             CRS13840
ISN 0549          FSPBAR(I,K) = SK-FSPU/XKE(I,K)                          CRS13850
              C (15A)                                                     CRS13860
ISN 0550      190 VX = AI(3*K)*FSPO                                       CRS13870
ISN 0551          XVOC(3,K) = VX                                          CRS13880
ISN 0552          VI = VFEDOT(1,K)                                        CRS13890
```

Figure 108. (Continued)

```
ISN 0553            V2 = VEEDOT(2,K)                                 CRS13900
ISN 0554            VBB = SQRT(V1*V1+V2*V2)                          CRS13910
ISN 0555            IF(VBB) 210,210,200                              CRS13920
ISN 0556        200 VX = XMU(1,K)*VX/VBB                             CRS13930
ISN 0557            XVOL(1,K) = VX*VEEDOT(1,K)                       CRS13940
ISN 0558            XVOL(2,K) = VX*VEEDOT(2,K)                       CRS13950
ISN 0559        210 IS = 0                                           CRS13960
              C LOOP C                                               CRS13970
ISN 0560            DO 220 J = 1,3                                   CRS13980
ISN 0561            SUM = 0.0                                        CRS13990
              C LOOP R                                               CRS14000
ISN 0562            DO 230 L = 1,3                                   CRS14010
ISN 0563            IS = IS+1                                        CRS14020
ISN 0564        230 SUM = SUM-AI(IS)*XVOL(L,K)                       CRS14030
ISN 0565        220 FSP(J,K) = SUM                                   CRS14040
              C END OF LOOP N                                        CRS14050
ISN 0566        105 CONTINUE                                         CRS14060
              C CRASH FORCES                                         CRS14070
ISN 0567            DO 240 J = 1,3                                   CRS14080
ISN 0568            SUM = 0.0                                        CRS14090
ISN 0569            DO 250 K = 1,3                                   CRS14100
ISN 0570        250 SUM = SUM+FSP(J,K)                               CRS14110
ISN 0571        240 XC(J) = SUM                                      CRS14120
ISN 0572            DXYZ(1) = DX(1)
ISN 0573            DXYZ(2) = DY(1)
ISN 0574            DXYZ(3) = DZ(1)
ISN 0575            DPQRIN(1) = DCIN(1)
ISN 0576            DPQRIN(2) = DRIN(1)
ISN 0577            DPQRIN(3) = DPIN(1)
ISN 0578            DPQRIN(4) = DQIN(1)
ISN 0579            TERM(1) = FSP(3,1)*XLNGTH(1)
ISN 0580            TERM(2) = FSP(1,2)*XLNGTH(2)
ISN 0581            TERM(3) = FSP(2,3)*XLNGTH(3)
ISN 0582            TERM(4) = FSP(2,1)*XLNGTH(1)
ISN 0583            TERM(5) = FSP(3,2)*XLNGTH(2)
ISN 0584            TERM(6) = FSP(1,3)*XLNGTH(3)
              C CRASH MOMENTS                                        CRS14130
ISN 0585            XC(4) = TERM(5)-TERM(3)
ISN 0586            XC(5) = TERM(6)-TERM(1)
ISN 0587            XC(6) = TERM(4)-TERM(2)
ISN 0588            CALL MATVEC(AI,DXYZ,DXYZPR,1)
ISN 0589            DO 260 K = 1,3
ISN 0590            IF(IISP(K).EQ.0) GO TO 260
ISN 0592            SUM = 0.0
ISN 0593            DO 270 J = 1,3
ISN 0594        270 SUM = SUM-FSP(J,K)*DXYZPR(J)
ISN 0595            CEIK(I,K) = CEIK(I,K)+SUM+TERM(K)*DPQRIN(K)-TERM(K+3)*DPQRIN(K+1)
ISN 0596        260 CONTINUE
              C                                                      CRS14170
ISN 0597            RETURN                                           CRS14180
              C*******************************                       CRS14190
              C*******************************                       CRS14200
ISN 0598            ENTRY IC                                         CRS14210
              C*******************************                       CRS14220
```

Figure 108. (Continued)

```
                C********************************                     CRS14230
ISN 0599              DIMENSION XMPR(3),ABARPR(3,3),ANGDPR(3),DPR(3,3),AIDP(3,3),   CRS14240
                     1 AIC(3,3),ADPR(3,3),VJP(60,3),APR(3,3),VIP(3),XV(3)            CRS14250
ISN 0600              EQUIVALENCE (PPR,XMPR(1)),(QPR,XMPR(2)),(RPR,XMPR(3)),        CRS14260
                     1 (PHIDPR,ANGDPR(1)),(THEDPR,ANGDPR(2)),(PSIDPR,ANGDPR(3))     CRS14270
ISN 0601              WTOT = 0.0                                                    CRS14280
ISN 0602              DO 2010 I = 1,NM                                              CRS14290
ISN 0603         2010 WTOT = WTOT+WGT(I)                                            CRS14300
ISN 0604              XGDP = 0.0                                                    CRS14310
ISN 0605              YGDP = 0.0                                                    CRS14320
ISN 0606              ZGDP = 0.0                                                    CRS14330
ISN 0607              DO 2020 I = 1,NM                                              CRS14340
ISN 0608              XGDP = XGDP+WGT(I)*XDP(I)                                     CRS14350
ISN 0609              YGDP = YGDP+WGT(I)*YDP(I)                                     CRS14360
ISN 0610         2020 ZGDP = ZGDP+WGT(I)*ZDP(I)                                     CRS14370
ISN 0611              XGDP = XGDP/WTOT                                              CRS14380
ISN 0612              YGDP = YGDP/WTOT                                              CRS14390
ISN 0613              ZGDP = ZGDP/WTOT                                              CRS14400
                C APRIME AND ABARPRIME (3)                                          CRS14410
ISN 0614              CALL EULER(APR,PHIPR,THEPR,PSIPR)                             CRS14420
ISN 0615              S1 = SIN(PHIPR)                                               CRS14430
ISN 0616              C1 = COS(PHIPR)                                               CRS14440
ISN 0617              S2 = SIN(THEPR)                                               CRS14450
ISN 0618              C2 = COS(THEPR)                                               CRS14460
                C NOW ABARPRIME (4)                                                 CRS14470
ISN 0619              ABARPR(1,1) = 1.0                                             CRS14480
ISN 0620              ABARPR(2,1) = 0.0                                             CRS14490
ISN 0621              ABARPR(3,1) = 0.0                                             CRS14500
ISN 0622              ABARPR(1,2) = S1*S2/C2                                        CRS14510
ISN 0623              ABARPR(2,2) = C1                                              CRS14520
ISN 0624              ABARPR(3,2) = S1/C2                                           CRS14530
ISN 0625              ABARPR(1,3) = C1*S2/C2                                        CRS14540
ISN 0626              ABARPR(2,3) = -S1                                             CRS14550
ISN 0627              ABARPR(3,3) = C1/C2                                           CRS14560
                C ANGLE DOT PRIMES (6)                                              CRS14570
ISN 0628              CALL MATVEC(ABARPR,XMPR,ANGDPR,0)                             CRS14580
                C D PRIME (7)                                                       CRS14590
ISN 0629              DPR(1,1) = 0.0                                                CRS14600
ISN 0630              DPR(1,2) = THEDPR*S1-PSIDPR*C1*C2                             CRS14610
ISN 0631              DPR(1,3) = THEDPR*C1+PSIDPR*S1*C2                             CRS14620
ISN 0632              DPR(2,1) = -DPR(1,2)                                          CRS14630
ISN 0633              DPR(2,2) = 0.0                                                CRS14640
ISN 0634              DPR(2,3) = -PHIDPR+PSIDPR*S2                                  CRS14650
ISN 0635              DPR(3,1) = -DPR(1,3)                                          CRS14660
ISN 0636              DPR(3,2) = -DPR(2,3)                                          CRS14670
ISN 0637              DPR(3,3) = 0.0                                                CRS14680
                C A DOT PRIME (8)                                                   CRS14690
ISN 0638              CALL MATMUL(APR,DPR,ADPR)                                     CRS14700
ISN 0639              ZCMAX = 0.0                                                   CRS14710
                C LOOP A                                                            CRS14720
ISN 0640              DO 2040 I = 1,NM                                              CRS14730
                C AI DOUBLE PRIME (9)                                               CRS14740
ISN 0641              CALL EULER(AIDP,PHIDP(I),THEDP(I),PSIDP(I))                   CRS14750
                C AI (10)                                                           CRS14760
```

Figure 108. (Continued)

```
ISN 0642          CALL MATMUL(APR,AILP,AIC)                               CRS14770
ISN 0643          THETA(I) = -ARSIN(AIC(3,1))                             CRS14780
ISN 0644          CT = 1.0/COS(THETA(I))                                  CRS14790
ISN 0645          PHI(I) = ARSIN(AIC(3,2)*CT)                             CRS14800
ISN 0646          PSI(I) = ARSIN(AIC(2,1)*CT)                             CRS14810
            C (12)                                                        CRS14820
ISN 0647          VJP(I,1) = XGDP-XDP(I)                                  CRS14830
ISN 0648          VJP(I,2) = YGDP-YDP(I)                                  CRS14840
ISN 0649          VJP(I,3) = ZGDP-ZDP(I)                                  CRS14850
            C LOOP B                                                      CRS14860
ISN 0650          DO 2050 K = 1,3                                         CRS14870
ISN 0651          IF(ISP(I,K)) 2060,2050,2060                             CRS14880
ISN 0652     2060 VC = AIC(3,K)*XL(IAK(I,K))                              CRS14890
ISN 0653          DO 2070 L = 1,3                                         CRS14900
ISN 0654     2070 VC = VC+APR(3,L)*VJP(I,L)                               CRS14910
ISN 0655          IF(VC-ZCMAX) 2050,2050,2080                             CRS14920
ISN 0656     2080 ZCMAX = VC                                              CRS14930
ISN 0657     2050 CONTINUE                                                CRS14940
            C END OF LOOP A                                               CRS14950
ISN 0658     2040 CONTINUE                                                CRS14960
ISN 0659          IF(ZC) 2220,2210,2220                                   CRS14970
ISN 0660     2210 ZC = -ZCMAX-.0100                                       CRS14980
            C SEE IF PHI'S, ETC. ARE ALL ZERO                             CRS14990
ISN 0661     2220 DO2100 I = 1,NM                                         CRS15000
ISN 0662          IF(PHIDP(I)) 2150,2110,2150                             CRS15010
ISN 0663     2110 IF(THEDP(I)) 2150,2120,2150                             CRS15020
ISN 0664     2120 IF(PSIDP(I)) 2150,2100,2150                             CRS15030
ISN 0665     2100 CONTINUE                                                CRS15040
            C IF WE GET HERE WE COMPUTE NEW THETA(I,J) AND PSI(I,J)       CRS15050
ISN 0666          PI = 3.14159265358979324D0                              CRS15060
ISN 0667          PI2 = .500*PI                                           CRS15070
ISN 0668          DO 2200 IJ = 1,IGS                                      CRS15080
ISN 0669          I = IG(IJ)                                              CRS15090
ISN 0670          J = JG(IJ)                                              CRS15100
ISN 0671          XIJP = VJP(J,1)-VJP(I,1)                                CRS15110
ISN 0672          YIJP = VJP(J,2)-VJP(I,2)                                CRS15120
ISN 0673          ZIJP = VJP(J,3)-VJP(I,3)                                CRS15130
ISN 0674          IF(YIJP) 2140,2130,2140                                 CRS15140
ISN 0675     2130 IF(XIJP) 2180,2170,2180                                 CRS15150
ISN 0676     2180 PSIIJ(IJ) = 0.0                                         CRS15160
ISN 0677          THEIJ(IJ) = -ATAN2(ZIJP,XIJP)                           CRS15170
ISN 0678          GO TO 2200                                              CRS15180
ISN 0679     2170 PSIIJ(IJ) = 0.0                                         CRS15190
ISN 0680          THEIJ(IJ) = -PI2                                        CRS15200
ISN 0681          IF(ZIJP) 2160,2200,2200                                 CRS15210
ISN 0682     2160 THEIJ(IJ) = PI2                                         CRS15220
ISN 0683          GO TO 2200                                              CRS15230
ISN 0684     2140 PSIIJ(IJ) = ATAN2(YIJP,XIJP)                            CRS15240
ISN 0685          THEIJ(IJ) = -ATAN2(ZIJP,SQRT(XIJP*XIJP+YIJP*YIJP))      CRS15250
ISN 0686     2200 CONTINUE                                                CRS15260
            C LOOPC                                                       CRS15270
ISN 0687     2150 DO 2090 I = 1,NM                                        CRS15280
ISN 0688          VIP(1) = VJP(I,1)                                       CRS15290
ISN 0689          VIP(2) = VJP(I,2)                                       CRS15300
```

Figure 108. (Continued)

```
ISN 0690          VIP(3) = VJP(I,3)                                      CRS15310
            C (14)                                                       CRS15320
ISN 0691          CALL MATVEC(APR,VIP,XV,0)                              CRS15330
ISN 0692          XV(3) = XV(3)+ZG                                       CRS15340
ISN 0693          X(I) = XV(1)                                           CRS15350
ISN 0694          Y(I) = XV(2)                                           CRS15360
ISN 0695          Z(I) = XV(3)                                           CRS15370
            C (15)                                                       CRS15380
ISN 0696          CALL MATVEC(AUPR,VIP,XV,0)                             CRS15390
ISN 0697          XV(1) = XV(1)+XGDOT                                    CRS15400
ISN 0698          XV(2) = XV(2)+YGDOT                                    CRS15410
ISN 0699          XV(3) = XV(3)+ZGDOT                                    CRS15420
ISN 0700          XDOT(I) = XV(1)                                        CRS15430
ISN 0701          YDOT(I) = XV(2)                                        CRS15440
ISN 0702          ZDOT(I) = XV(3)                                        CRS15450
            C (16)                                                       CRS15460
ISN 0703          CALL MATVEC(AIC,XV,VIP,1)                              CRS15470
ISN 0704          U(I) = VIP(1)                                          CRS15480
ISN 0705          V(I) = VIP(2)                                          CRS15490
ISN 0706          W(I) = VIP(3)                                          CRS15500
            C (17)                                                       CRS15510
ISN 0707          CALL MATVEC(AIDP,XMPR,VIP,1)                           CRS15520
ISN 0708          P(I) = VIP(1)                                          CRS15530
ISN 0709          Q(I) = VIP(2)                                          CRS15540
ISN 0710          R(I) = VIP(3)                                          CRS15550
            C AIBAR (18)                                                 CRS15560
ISN 0711          S1 = SIN(PHI(I))                                       CRS15570
ISN 0712          C1 = COS(PHI(I))                                       CRS15580
ISN 0713          S2 = SIN(THETA(I))                                     CRS15590
ISN 0714          C2 = COS(THETA(I))                                     CRS15600
ISN 0715          ABARPR(1,2) = S1*S2/C2                                 CRS15610
ISN 0716          ABARPR(2,2) = C1                                       CRS15620
ISN 0717          ABARPR(3,2) = S1/C2                                    CRS15630
ISN 0718          ABARPR(1,3) = C1*S2/C2                                 CRS15640
ISN 0719          ABARPR(2,3) = -S1                                      CRS15650
ISN 0720          ABARPR(3,3) = C1/C2                                    CRS15660
            C (19)                                                       CRS15670
ISN 0721          CALL MATVEC(ABARPR,VIP,XV,0)                           CRS15680
ISN 0722          PHIDOT(I) = XV(1)                                      CRS15690
ISN 0723          THEDOT(I) = XV(2)                                      CRS15700
ISN 0724          PSIDOT(I) = XV(3)                                      CRS15710
            C END LOOP C                                                 CRS15720
ISN 0725     2090 CONTINUE                                               CRS15730
ISN 0726          PRINT 2301                                             CRS15740
ISN 0727     2301 FORMAT(1H0,'IJ,THEIJ(IJ),PSIIJ(IJ)' )                  CRS15750
ISN 0728          PRINT 2300,(IJ,THEIJ(IJ),PSIIJ(IJ),IJ=1,IGS)           CRS15760
ISN 0729     2300 FORMAT (1H ,I5,1P2E15.5)                               CRS15770
ISN 0730          RETURN                                                 CRS15780
            C********************************                            CRS15790
            C********************************                            CRS15800
ISN 0731          ENTRY PRINT                                            CRS15810
            C********************************                            CRS15820
            C********************************                            CRS15830
ISN 0732          REAL*4 KEI(60),PEI 60)
```

Figure 108. (Continued)

```
ISN 0733          DIMENSION VEE2(6,80)                                      CRS15840
ISN 0734          EQUIVALENCE (VEE(1),VEE2(1))                              CRS15850
ISN 0735          ILINES = 60                                               CRS15860
ISN 0736          IPL = 6                                                   CRS15870
ISN 0737          ITTL = 9                                                  CRS15880
            C FORCE NEW PAGE                                                CRS15890
ISN 0738          NPK = 1000                                                CRS15900
ISN 0739          DO 3099 I = 1,NM                                          CRS15910
ISN 0740          IF (ILINES-NPK-IPL) 3010,3020,3020                        CRS15920
ISN 0741     3010 PRINT 3100,TITLE                                          CRS15930
ISN 0742     3100 FORMAT(1H1,10A6,/)                                        CRS15940
ISN 0743          PRINT 3200,TIME                                           CRS15950
ISN 0744     3200 FORMAT(1H ,6HTIME =,F9.5,/)                               CRS15960
ISN 0745          PRINT 3300                                                CRS15970
ISN 0746          PRINT 400                                                 CRS15980
ISN 0747          PRINT 500                                                 CRS15990
ISN 0748          PRINT 600                                                 CRS16000
ISN 0749          PRINT 900                                                 CRS16010
ISN 0750     3300 FORMAT(1H ,16X,1HX,14X,1HY,14X,1HZ,13X,3HPHI,11X,5HTHETA, CRS16020
                 1  11X,3HPSI)                                              CRS16030
ISN 0751      400 FORMAT(1H ,17X,4HXDOT,11X,4HYDOT,11X,4HZDOT,10X,6HPHIDOT, CRS16040
                 1  8X,8HTHETADOT,6X,6HPSIDOT)                              CRS16050
ISN 0752      500 FORMAT(1H ,16X,1HU,14X,1HV,14X,1HW,14X,1HP,14X,1HQ,14X,1HR) CRS16060
ISN 0753      600 FORMAT(1H ,17X,4HUDOT,11X,4HVDOT,11X,4HWDOT,11X,4HPDOT,11X, CRS16070
                 1  4HQDOT,11X,4HRDOT)                                      CRS16080
ISN 0754      900 FORMAT (1H ,16X,6HXACCEL,9X,6HYACCEL,9X,6HZACCEL,/)       CRS16090
ISN 0755          NPK = ITTL                                                CRS16100
ISN 0756     3020 NPK = NPK+IPL                                             CRS16110
ISN 0757          PRINT 700, I,X(I),Y(I),Z(I),PHI(I),THETA(I),PSI(I)        CRS16120
ISN 0758          PRINT 800, XDOT(I),YDOT(I),ZDOT(I),PHIDOT(I),THEDOT(I),PSIDOT(I) CRS16130
ISN 0759          PRINT 800, U(I),V(I),W(I),P(I),Q(I),R(I)                  CRS16140
ISN 0760          PRINT 800, UDOT(I),VDOT(I),WDOT(I),PDOT(I),QDOT(I),RDOT(I) CRS16150
ISN 0761          PRINT 800, XACC(I),YACC(I),ZACC(I)                        CRS16160
ISN 0762          PRINT 800                                                 CRS16170
ISN 0763      700 FORMAT(1H ,5HMASS ,I2,2X,1P6E15.5)                        CRS16180
ISN 0764      800 FORMAT(1H ,5X,1P6E15.5)                                   CRS16190
ISN 0765     3099 CONTINUE                                                  CRS16200
ISN 0766          PRINT 830                                                 CRS16210
ISN 0767      830 FORMAT(1H ,'IG(IJ),JG(IJ),SUMDF(1,IJ),SUMDF(2,IJ),SUMDF(3,IJ),' CRS16220
                 :  'SUMDF(4,IJ),SUMDF(5,IJ),SUMDF(6,IJ)')                  CRS16230
ISN 0768          PRINT 810,(IG(IJ),JG(IJ),(SUMDF(K,IJ),K=1,6),IJ=1,IGS)    CRS16240
ISN 0769          PRINT 831                                                 CRS16250
ISN 0770      831 FORMAT(1H ,'IG(IJ),JG(IJ),VEE2(1,IJ),VEE2(2,IJ),VEE2(3,IJ),VEE2(4,CRS16260
                 1IJ),VEE2(5,IJ),VEE2(6,IJ)' )                              CRS16270
ISN 0771          PRINT 810,(IG(IJ),JG(IJ),(VEE2(K,IJ),K=1,6),IJ=1,IGS)     CRS16280
ISN 0772      810 FORMAT (1H ,1X,I2,2X,I2,2X,1P6E15.5)                      CRS16290
ISN 0773          PRINT 832                                                 CRS16300
ISN 0774      832 FORMAT(1H ,'I,SC(I,1),SC(I,2),SC(I,3)' )                  CRS16310
ISN 0775          DO 3040 I = 1,NM                                          CRS16320
ISN 0776          DO 3050 J = 1,3                                           CRS16330
ISN 0777          IF(ISP(I,J).NE.0) GO TO 3060                              CRS16340
ISN 0779     3050 CONTINUE                                                  CRS16350
ISN 0780          GO TO 3040                                                CRS16360
ISN 0781     3060 PRINT 820, I,(SC(I,J),J=1,3)                              CRS16370
```

Figure 108. (Continued)

```
ISN 0762        820 FORMAT(1H ,I7,2X,1P3E15.5)                              CRS16380
ISN 0763       3040 CONTINUE                                                CRS16390
ISN 0764            ISET=0                                                  CRS16400
ISN 0765            DO 3070 I = 1,IGS                                       CRS16410
ISN 0766            IF(IJPR(I).EQ.BLANK) GO TO 3070                         CRS16420
ISN 0768            IF (ISET.EQ.1)  GO TO 3065                              CRS16430
ISN 0790            PRINT 821                                               CRS16440
ISN 0791        821 FORMAT(1H //1X,'MASS',7X,'DRI')                         CRS16450
ISN 0792            ISET=1                                                  CRS16460
ISN 0793       3065 PRINT 822, JG(I),DRI(I)                                 CRS16470
ISN 0794       3070 CONTINUE                                                CRS16480
ISN 0795        822 FORMAT(1H ,1X,I2,3X,1PE15.5)                            CRS16490
ISN 0796            SUMKEI = 0.0
ISN 0797            SUMPEI = 0.0
ISN 0798            SUMSEI = 0.0
ISN 0799            SUMDEI = 0.0
ISN 0800            SUMCEI = 0.0
ISN 0801            DO 3400 I = 1,NM
          C*****DON'T USE AN I IF IT'S = TO A J OF A DRI I,J PAIR
ISN 0802            DO 3408 IJ = 1,IGS
ISN 0803            IF(IJPP(IJ).EQ.BLANK) GO TO 3408
ISN 0805            IF(I.NE.JG(IJ)) GO TO 3408
ISN 0807            PEI(I) = 0.0
ISN 0808            KEI(I) = 0.0
ISN 0809            GO TO 3400
ISN 0810       3408 CONTINUE
ISN 0811            PEI(I) = -WGT(I)*Z(I)
ISN 0812            SUMPEI = SUMPEI+PEI(I)
ISN 0813            KEI(I) = .5*(WGT(I)*(U(I)*U(I)+V(I)*V(I)+W(I)*W(I))/386.0
                   1 +P(I)*(P(I)* XI(I)+Q(I)*XYI(I)+R(I)*XZI(I))
                   2 +Q(I)*(P(I)*XYI(I)+Q(I)* YI(I)+R(I)*YZI(I))
                   3 +R(I)*(P(I)*XZI(I)+Q(I)*YZI(I)+R(I)* ZI(I)))
ISN 0814            SUMKEI = SUMKEI+KEI(I)
ISN 0815       3400 CONTINUE
ISN 0816            DO 3406 IJ = 1,IGS
ISN 0817            SUMSEI = SUMSEI+SEIJ(IJ)
ISN 0818       3406 SUMDEI = SUMDEI+DEIJ(IJ)
ISN 0819            IF(IKCT.EQ.0) GO TO 3409
ISN 0821            DO 3407 IK = 1,IKCT
ISN 0822       3407 SUMCEI = SUMCEI+CLIK(II(IK),KK(IK))
ISN 0823       3409 ETOT = SUMKEI+SUMPEI+SUMSEI+SUMDEI+SUMCEI
ISN 0824            PRINT 3401
ISN 0825       3401 FORMAT(1H0,6X,'TOTAL',7X,'KINETIC',6X,'POTENTIAL',7X,'STRAIN',7X,
                   1 'DAMPING',7X,'CRUSHING',/6X,'ENERGY',5(8X,'ENERGY')/)
ISN 0826            PRINT 3402, ETOT,SUMKEI,SUMPEI,SUMSEI,SUMDEI,SUMCEI
ISN 0827       3402 FORMAT(1X,1P6E14.5)
ISN 0828            PCKE = SUMKEI/ETOT
ISN 0829            PCPE = SUMPEI/ETOT
ISN 0830            PCSE = SUMSEI/ETOT
ISN 0831            PCDE = SUMDEI/ETOT
ISN 0832            PCCE = SUMCEI/ETOT
ISN 0833            PRINT 3403, PCKE,PCPE,PCSE,PCDE,PCCE
ISN 0834       3403 FORMAT('0  PERCENT OF',2P5F14.3/3X,'TOTAL ENERGY')
ISN 0835            PRINT 3404
```

Figure 108. (Continued)

```
ISN 0836     3404 FORMAT('C',50X,'INTERNAL',46X,'EXTERNAL'/53X,'BEAM',49X,'SPRING'/
                 1 7X,'KINETIC',15X,'POTENTIAL',26X,'STRAIN',17X,'DAMPING',20X,
                 2 'CRUSHING'/' MASS  ENERGY     PER CENT     ENERGY     PER CENT   I
                 3J  I  J    ENERGY     PER CENT      ENERGY     PER CENT    I K     ENER
                 4GY    PER CENT'/)
ISN 0837          MAXEN = MAX0(NM,IGS,IKCT)
ISN 0838          IF(TIME.EQ.0.0) MAXEN = NM
ISN 0840          DO 3410 IO = 1,MAXEN
ISN 0841          IOPTR = 0
ISN 0842          IF(IO.GT.NM) GO TO 3411
ISN 0844          IOPTR = IOPTR+4
ISN 0845          PCKE = KEI(IO)/SUMKEI
ISN 0846          PCPE = PEI(IO)/SUMPEI
ISN 0847          IF(TIME.EQ.0.0) GO TO 3504
ISN 0849     3411 IF(IO.GT.IGS) GO TO 3412
ISN 0851          IOPTR = IOPTR+2
ISN 0852          PCSE = SEIJ(IO)/SUMSEI
ISN 0853          PCDE = DEIJ(IO)/SUMDEI
ISN 0854     3412 IF(IO.GT.IKCT) GO TO 3413
ISN 0856          IOPTR = IOPTR+1
ISN 0857          I = II(IO)
ISN 0858          K = KK(IO)
ISN 0859          CE = CEIK(I,K)
ISN 0860          PCCE = CE/SUMCEI
ISN 0861     3413 GO TO (3501,3502,3503,3504,3505,3506,3507), IOPTR
             C******ONLY CE
ISN 0862     3501 PRINT 3511,I,K,CE,PCCE
ISN 0863     3511 FORMAT(165X,I3,I2,1PE13.5,2PF9.3)
ISN 0864          GO TO 3410
             C******SE AND DE
ISN 0865     3502 PRINT 3512,IO,IG(IO),JG(IO),SEIJ(IO),PCSE,DEIJ(IO),PCDE
ISN 0866     3512 FORMAT(51X,3I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3)
ISN 0867          GO TO 3410
             C******SE, DE, CE
ISN 0868     3503 PRINT 3513,IO,IG(IO),JG(IO),SEIJ(IO),PCSE,DEIJ(IO),PCDE,I,K,CE,
                 1 PCCE
ISN 0869     3513 FORMAT(51X,3I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3,I4,I2,1PE13.5,2PF9.3)
ISN 0870          GO TO 3410
             C******KE AND PE
ISN 0871     3504 PRINT 3514,IO,KEI(IO),PCKE,PEI(IO),PCPE
ISN 0872     3514 FORMAT(1X,I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3)
ISN 0873          GO TO 3410
             C******KE, PE, CE
ISN 0874     3505 PRINT 3515,IO,KEI(IO),PCKE,PEI(IO),PCPE,I,K,CE,PCCE
ISN 0875     3515 FORMAT(1X,I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3,58X,2I2,1PE13.5,2PF9.3)
ISN 0876          GO TO 3410
             C******KE, PE, SE, DE
ISN 0877     3506 PRINT 3516,IO,KEI(IO),PCKE,PEI(IO),PCPE,IO,IG(IO),JG(IO),SEIJ(IO),
                 1 PCSE,DEIJ(IO),PCDE
ISN 0878     3516 FORMAT(1X,I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3,2X,3I3,1PE13.5,2PF9.3,
                 1 1PE14.5,2PF9.3)
ISN 0879          GO TO 3410
             C******KE, PE, SE, DE, CE
ISN 0880     3507 PRINT 3517,IO,KEI(IO),PCKE,PEI(IO),PCPE,IO,IG(IO),JG(IO),SEIJ(IO),
```

Figure 108. (Continued)

```
                     1 PCSE,DELIJ(10),PCDE,I,K,CE,PCCE
ISN 0881      3517 FORMAT(1X,I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3,2X,3I3,1PE13.5,2PF9.3,
                   1 1PE14.5,2PF9.3,I4,I2,1PE13.5,2PF9.3)
ISN 0882      3410 CONTINUE
ISN 0883           RETURN                                                       CRS16500
              C**********************************                               CRS16510
              C**********************************                               CRS16520
ISN 0884           ENTRY SAVE                                                   CRS16530
              C**********************************                               CRS16540
              C**********************************                               CRS16550
ISN 0885           REAL*4 PLOT,ZAK,TMPLOT                                       CRS16560
ISN 0886           IPLC = 0                                                     CRS16570
ISN 0887           JPLOT = JPLOT+1                                              CRS16580
ISN 0888           IF(JPLOT.GT.IP) RETURN                                       CRS16590
ISN 0890           TMPLOT(JPLOT) = TIME                                         CRS16600
ISN 0891           DO 39 I = 1,NPLOT                                            CRS16610
ISN 0892           IS = IPLOT(I)                                                CRS16620
ISN 0893           ID = IDPLOT(I)                                               CRS16630
ISN 0894           GO TO (1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21, CRS16640
                  1      22,23,24,25), ID                                       CRS16650
ISN 0895         1 T = X(IS)                                                    CRS16660
ISN 0896           GO TO 39                                                     CRS16670
ISN 0897         2 T = Y(IS)                                                    CRS16680
ISN 0898           GO TO 39                                                     CRS16690
ISN 0899         3 T = Z(IS)                                                    CRS16700
ISN 0900           GO TO 39                                                     CRS16710
ISN 0901         4 T = XDOT(IS)                                                 CRS16720
ISN 0902           GO TO 39                                                     CRS16730
ISN 0903         5 T = YDOT(IS)                                                 CRS16740
ISN 0904           GO TO 39                                                     CRS16750
ISN 0905         6 T = ZDOT(IS)                                                 CRS16760
ISN 0906           GO TO 39                                                     CRS16770
ISN 0907         7 T = XACC(IS)                                                 CRS16780
ISN 0908           GO TO 39                                                     CRS16790
ISN 0909         8 T = YACC(IS)                                                 CRS16800
ISN 0910           GO TO 39                                                     CRS16810
ISN 0911         9 T = ZACC(IS)                                                 CRS16820
ISN 0912           GO TO 39                                                     CRS16830
ISN 0913        10 T = SC(IS,1)                                                 CRS16840
ISN 0914           GO TO 39                                                     CRS16850
ISN 0915        11 T = SC(IS,2)                                                 CRS16860
ISN 0916           GO TO 39                                                     CRS16870
ISN 0917        12 T = SC(IS,3)                                                 CRS16880
ISN 0918           GO TO 39                                                     CRS16890
ISN 0919        13 T = VEE2(1,IS)                                               CRS16900
ISN 0920           GO TO 39                                                     CRS16910
ISN 0921        14 T = VEE2(2,IS)                                               CRS16920
ISN 0922           GO TO 39                                                     CRS16930
ISN 0923        15 T = VEE2(3,IS)                                               CRS16940
ISN 0924           GO TO 39                                                     CRS16950
ISN 0925        16 T = VEE2(4,IS)                                               CRS16960
ISN 0926           GO TO 39                                                     CRS16970
ISN 0927        17 T = VEE2(5,IS)                                               CRS16980
ISN 0928           GO TO 39                                                     CRS16990
```

Figure 108. (Continued)

PAGE 021

```
ISN 0929     18 T = VEE2(6,IS)                                  CRS17000
ISN 0930        GO TO 39                                        CRS17010
ISN 0931     19 T = SUMDF(1,IS)                                 CRS17020
ISN 0932        GO TO 39                                        CRS17030
ISN 0933     20 T = SUMDF(2,IS)                                 CRS17040
ISN 0934        GO TO 39                                        CRS17050
ISN 0935     21 T = SUMDF(3,IS)                                 CRS17060
ISN 0936        GO TO 39                                        CRS17070
ISN 0937     22 T = SUMDF(4,IS)                                 CRS17080
ISN 0938        GO TO 39                                        CRS17090
ISN 0939     23 T = SUMDF(5,IS)                                 CRS17100
ISN 0940        GO TO 39                                        CRS17110
ISN 0941     24 T = SUMDF(6,IS)                                 CRS17120
ISN 0942        GO TO 39                                        CRS17130
ISN 0943     25 T=DRI(IS)                                       CRS17140
ISN 0944     39 PLOT(IP*(I-1)+JPLOT) = T                        CRS17150
ISN 0945        RETURN                                          CRS17160
ISN 0946        END                                             CRS17170
```

Figure 108. (Continued)

```
LEVEL 20.1 (MAY 71)                    OS/360  FORTRAN H                    DATE  73.298/10.03.38

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                    SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
ISN 0002            SUBROUTINE TCLP                                                  CRS17180
ISN 0003            IMPLICIT REAL*8 (A-H,O-Z)                                         CRS17190
ISN 0004            REAL*4 DELX,DFLY,DLX,DLY,XFMT,YFMT,YMIN,YMAX,XMIN,XMAX            CRS17200
ISN 0005            REAL*4 PLOT,ZAR,TMPLOT                                            CRS17210
ISN 0006            INTEGER*2 IJPR,      IDPLOT,    ISP,    N,NN                      CRS17220
ISN 0007            DIMENSION IYCHAR(3),LIT(3),NAMES(25)                              CRS17230
ISN 0008            COMMON/COMALL/ C(6,60),P(60),Q(60),R(60),U(60),V(60),W(60),X(60), CRS00160
                   1 Y(60),Z(60),AI(9),AJ(9),FM(2880),SC(60,3),XC(6),XK(2880),XI(60), CRS00170
                   2 YI(60),ZI(60),XYI(60),XZI(60),YZI(60),AIJ(9),BIJ(540),DIJ(720),  CRS00180
                   3 DKI(60),UAI(540),VEF(480),WGT(60),PHI(60),THETA(60),PSI(60),     CRS00190
                   4 PDOT(60),QDOT(60),RDOT(60),UDOT(60),VDOT(60),WDOT(60),XDOT(60),  CRS00200
                   5 YDOT(60),ZDOT(60),PHIDOT(60),THEDOT(60),PSIDOT(60),TIME,DELTAT,  CRS00210
                   6 XACC(60),YACC(60),ZACC(60),AITAJ(9),AIDOT(9),FMBAR(2880),        CRS00220
                   7 PHIIJ(80),THEIJ(80),PSIIJ(80),SUMDF(6,80),TITLE(10),XLBAR(60,3), CRS00230
                   8 FSPBAR(60,3),VEEDOT(3,3),DX(60),DY(60),DZ(60),DPIN(60),DRIN(60), CRS00240
                   8 DOIN(60),SEIJ(80),DEIJ(80),CEIK(60,3),
                   9ZAR(200),PLOT(30000),TMPLOT(500),                                 CRS17330
                   ANN,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(150),IG(80),JG(80),    CRS17340
                   8 N(420),NN(60,3),ISP(60,3),IJPR(60),IDPLOT(150)                   CRS00270
ISN 0009            DATA LIT/'(  )','  (  ',',  )'/                                   CRS17370
ISN 0010            DATA NAMES/' X  ',' Y  ',' Z  ','XDOT','YDOT','ZDOT',             CRS17380
                   1            ' AX ',' AY ',' AZ ',' S1 ',' S2 ',' S3 ',            CRS17390
                   2            ' V1 ',' V2 ',' V3 ',' V4 ',' V5 ',' V6 ',            CRS17400
                   3            ' F1 ',' F2 ',' F3 ',' F4 ',' F5 ',' F6 ',            CRS17410
                   3            ' DRI'/                                               CRS17420
ISN 0011            IYCHAR(3) = LIT(3)                                                CRS17430
ISN 0012            IF(JPLOT.GT.IP) JPLOT = IP                                        CRS17440
ISN 0014            XMIN = TMPLOT(1)                                                  CRS17450
ISN 0015            XMAX = TMPLOT(JPLOT)                                              CRS17460
ISN 0016            IF(XMIN.EQ.XMAX) RETURN                                           CRS17470
              C IF 1ST TIME INITIALIZE                                                CRS17480
ISN 0018            IF(IPLSW.NE.0) GO TO 4005                                         CRS17490
ISN 0020            IPLSW = 1                                                         CRS17500
ISN 0021            CALL MODESG(ZAR,0)                                                CRS17510
ISN 0022            CALL SETSMG(ZAR,93,0.0)                                           CRS17520
ISN 0023            CALL SETSMG(ZAR,97,150.0)                                         CRS17530
ISN 0024            CALL SETSMG(ZAR,100,2.0)                                          CRS17540
ISN 0025       4005 IYCHAR(2) = LIT(1)                                                CRS17550
ISN 0026            NY = 8                                                            CRS17560
ISN 0027            DO 4010 I = 1,NPLOT                                               CRS17570
ISN 0028            IF (IDPLOT(I).EQ.25)  GO TO 4015                                  CRS17580
```

Figure 108. (Continued)

```
ISN 0030           IF(IDPLOT(I).LE.12) GO TO 4020                                    CRS17590
ISN 0032           NY = 12                                                           CRS17600
ISN 0033           IYCHAR(2) = LIT(2)                                                CRS17610
ISN 0034           CALL FMTSG(ZAR,1,4,0,IG(IPLOT(I)),IBUF)                           CRS17620
ISN 0035           CALLGETCZZ(ZAR,IHOLD,3,IBUF)                                      CRS17630
ISN 0036           CALLPUTCZZ(ZAR,IHOLD,3,IYCHAR(2))                                 CRS17640
ISN 0037           CALLGETCZZ(ZAR,IHOLD,4,IBUF)                                      CRS17650
ISN 0038           CALLPUTCZZ(ZAR,IHOLD,4,IYCHAR(2))                                 CRS17660
ISN 0039           CALL FMTSG(ZAR,1,4,0,JG(IPLOT(I)),IBUF)                           CRS17670
ISN 0040           CALLGETCZZ(ZAR,IHOLD,3,IBUF)                                      CRS17680
ISN 0041           CALLPUTCZZ(ZAR,IHOLD,2,IYCHAR(3))                                 CRS17690
ISN 0042           CALLGETCZZ(ZAR,IHOLD,4,IBUF)                                      CRS17700
ISN 0043           CALLPUTCZZ(ZAR,IHOLD,3,IYCHAR(3))                                 CRS17710
ISN 0044           GO TO 4030                                                        CRS17720
ISN 0045      4015 CALL FMTSG(ZAR,1,4,0,JG(IPLOT(I)),IBUF)                           CRS17730
ISN 0046           IYCHAR(2)=LIT(1)                                                  CRS17740
ISN 0047           NY=8                                                              CRS17750
ISN 0048           GO TO 4025                                                        CRS17760
ISN 0049      4020 CALL FMTSG(ZAR,1,4,0,IPLOT(I),IBUF)                               CRS17770
ISN 0050      4025 CALLGETCZZ(ZAR,IHOLD,3,IBUF)                                      CRS17780
ISN 0051           CALLPUTCZZ(ZAR,IHOLD,2,IYCHAR(2))                                 CRS17790
ISN 0052           CALLGETCZZ(ZAR,IHOLD,4,IBUF)                                      CRS17800
ISN 0053           CALLPUTCZZ(ZAR,IHOLD,3,IYCHAR(2))                                 CRS17810
ISN 0054      4030 IYCHAR(1) = NAMES(IDPLOT(I))                                      CRS17820
ISN 0055           YMIN = PLOT(IP*(I-1)+1)                                           CRS17830
ISN 0056           YMAX = YMIN                                                       CRS17840
ISN 0057           DO 4040 J = 2,JPLOT                                               CRS17850
ISN 0058           YMIN = AMIN1(YMIN,PLOT(IP*(I-1)+J))                               CRS17860
ISN 0059      4040 YMAX = AMAX1(YMAX,PLOT(IP*(I-1)+J))                               CRS17870
ISN 0060           IF (ABS(YMAX-YMIN).GT.1.E-7*ABS(YMAX))  GO TO 4050                CRS17880
ISN 0062           IF (ABS(YMAX).GT.1.E-7)  GO TO 4045                               CRS17890
ISN 0064           YMAX=1.                                                           CRS17900
ISN 0065           YMIN=-1.                                                          CRS17910
ISN 0066           GO TO 4050                                                        CRS17920
ISN 0067      4045 YMAX=YMAX+0.1*YMAX                                                CRS17930
ISN 0068           YMIN=YMIN-0.1*YMIN                                                CRS17940
ISN 0069      4050 CONTINUE                                                          CRS17950
ISN 0070           CALL SUBJEG(ZAR,XMIN,YMIN,XMAX,YMAX)                              CRS17960
ISN 0071           CALL SETUPG(ZAR,1,DELX,DELY,IXTH,JYTH,DLX,DLY,XFMT,YFMT)          CRS17970
ISN 0072           DO 4060 J = 106,109                                               CRS17980
ISN 0073      4060 ZAR(J) = 0.0                                                      CRS17990
ISN 0074           CALL GRIDG(ZAR,DELX,DELY,IXTH,JYTH)                               CRS18000
ISN 0075           CALL SETSMG(ZAR,45,1.0)                                           CRS18010
ISN 0076           CALL LABELG(ZAR,0,DLX,0,XFMT)                                     CRS18020
ISN 0077           CALL LABELG(ZAR,1,DLY,0,YFMT)                                     CRS18030
ISN 0078           CALL SETSMG(ZAR,45,1.5)                                           CRS18040
ISN 0079           CALL TITLEG(ZAR,14,14HTIME (SECONDS),NY,IYCHAR,70,TITLE)          CRS18050
ISN 0080           CALL LINESG(ZAR,JPLOT,TMPLOT,PLOT(IP*(I-1)+1))                    CRS18060
         C NEW FRAME                                                                 CRS18070
ISN 0081           CALL PAGEG(ZAR,0,1,1)                                             CRS18080
ISN 0082      4010 CONTINUE                                                          CRS18090
ISN 0083           RETURN                                                            CRS18100
ISN 0084           END                                                               CRS18110
```

Figure 108. (Continued)

```
LEVEL 20.1 (MAY 71)                    OS/360  FORTRAN H                    DATE  73.298/10.03.44

      COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                         SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
 ISN 0002         SUBROUTINE EULER(A,PHI,THETA,PSI)                              CRS18120
 ISN 0003         IMPLICIT REAL*8 (A-H,O-Z)                                      CRS18130
 ISN 0004         DIMENSION A(9)                                                 CRS18140
 ISN 0005         SIN(X) = DSIN(X)                                               CRS18150
 ISN 0006         COS(X) = DCOS(X)                                               CRS18160
 ISN 0007         S1 = SIN(PHI)                                                  CRS18170
 ISN 0008         C1 = COS(PHI)                                                  CRS18180
 ISN 0009         S2 = SIN(THETA)                                                CRS18190
 ISN 0010         C2 = COS(THETA)                                                CRS18200
 ISN 0011         S3 = SIN(PSI)                                                  CRS18210
 ISN 0012         C3 = COS(PSI)                                                  CRS18220
 ISN 0013         A(1) =  C2*C3                                                  CRS18230
 ISN 0014         A(2) =  C2*S3                                                  CRS18240
 ISN 0015         A(3) = -S2                                                     CRS18250
 ISN 0016         A(4) = -C1*S3+S1*S2*C3                                         CRS18260
 ISN 0017         A(5) =  C1*C3+S1*S2*S3                                         CRS18270
 ISN 0018         A(6) =  S1*C2                                                  CRS18280
 ISN 0019         A(7) =  S1*S3+C1*S2*C3                                         CRS18290
 ISN 0020         A(8) = -S1*C3+C1*S2*S3                                         CRS18300
 ISN 0021         A(9) =  C1*C2                                                  CRS18310
 ISN 0022         RETURN                                                         CRS18320
 ISN 0023         END                                                            CRS18330
```

Figure 108. (Continued)

```
LEVEL 20.1 (MAY 71)                    OS/360  FORTRAN H                    DATE  73.298/10.03.54

        COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                           SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
    ISN 0002            SUBROUTINE MATMUL(A,B,C)                                  CRS18340
    ISN 0003            IMPLICIT REAL*8 (A-H,O-Z)                                 CRS18350
    ISN 0004            DIMENSION A(3,3),B(3,3),C(3,3)                            CRS18360
                  C A*B TO C                                                      CRS18370
    ISN 0005            DO 10 I = 1,3                                             CRS18380
    ISN 0006            DO 10 J = 1,3                                             CRS18390
    ISN 0007            SUM = 0.0                                                 CRS18400
    ISN 0008            DO 20 K = 1,3                                             CRS18410
    ISN 0009         20 SUM = SUM+A(I,K)*B(K,J)                                   CRS18420
    ISN 0010         10 C(I,J) = SUM                                              CRS18430
    ISN 0011            RETURN                                                    CRS18440
    ISN 0012            END                                                       CRS18450
```

Figure 108. (Continued)

```
LEVEL 20.1 (MAY 71)                     OS/360  FORTRAN H                        DATE  73.296/10.04.05

      COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                         SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
 ISN 0002             SUBROUTINE MATVEC(A,V,P,ISW)                               CRS18460
 ISN 0003             IMPLICIT REAL*8 (A-H,O-Z)                                  CRS18470
 ISN 0004             DIMENSION A(3,3),V(3),P(3)                                 CRS18480
                C A*V TO P IF ISW = 0, ELSE AT*V TO P                            CRS18490
 ISN 0005             DO 10 I = 1,3                                              CRS18500
 ISN 0006             SUM = 0.0                                                  CRS18510
 ISN 0007             DO 20 K = 1,3                                              CRS18520
 ISN 0008             IF(ISW) 40,30,40                                           CRS18530
 ISN 0009          30 SUM = SUM+A(I,K)*V(K)                                      CRS18540
 ISN 0010             GO TO 20                                                   CRS18550
 ISN 0011          40 SUM = SUM+A(K,I)*V(K)                                      CRS18560
 ISN 0012          20 CONTINUE                                                   CRS18570
 ISN 0013          10 P(I) = SUM                                                 CRS18580
 ISN 0014             RETURN                                                     CRS18590
 ISN 0015             END                                                        CRS18600
```

Figure 108. (Continued)

REFERENCES

1. Wittlin, G., Gamon, M. A., EXPERIMENTAL PROGRAM FOR THE DEVELOPMENT OF IMPROVED HELICOPTER STRUCTURAL CRASHWORTHINESS ANALYTICAL AND DESIGN TECHNIQUES, Lockheed-California Company; USAAMRDL Technical Report 72-72A, 72B, Eustis Directorate, U. S. Army Air Mobility Research and Development Laboratory, Ft. Eustis, Virginia, May 1973, AD 764985.

2. Turnbow, J. W., Carroll, D. F., Haley, J. L., Jr., Robertson, S. N., CRASH SURVIVAL DESIGN GUIDE, Dynamic Science; USAAMRDL Technical Report 71-22, Eustis Directorate, U. S. Army Air Mobility and Research Laboratory, Ft. Eustis, Virginia, Oct. 1971, AD 733358.

3. Reed, William, H., Avery, James P., Ph.D., PRINCIPLES FOR IMPROVING STRUCTURAL CRASHWORTHINESS FOR STOL AND CTOL AIRCRAFT, Aviation Safety Engineering and Research; USAAVLABS Technical Report 66-39, U. S. Army Aviation Materiel Laboratories, Ft. Eustis, Virginia, June 1966, AD 637133.

4. Greer D. L., et al, DESIGN STUDY AND MODEL STRUCTURES TEST PROGRAM TO IMPROVE FUSELAGE CRASHWORTHINESS, General Dynamics, Convair, FAA Technical Report DS-67-20, Federal Aviation Administration, Washington, D.C., October 1967, AD 666816.

5. Saczalski, K. J., Park, K. C., TRANSIENT RESPONSE OF INELASTICITY CONSTRAINED RIGID BODY SYSTEMS, to appear in Journal of Engineering for Industry, ASME Transactions, 1974.

6. Massonnet, C. E., and Save, M. A., PLASTIC ANALYSIS AND DESIGN, VOL. I, BEAMS AND FRAMES: Blusdell Publishers, New York, 1965.

7. Roark, R. J., FORMULAS FOR STRESS AND STRAIN, McGraw-Hill Publishers, New York, 1965.

8. Ayre, Robert S., Shock and Vibration Hdbk., Chap. 8, Vol. 1, TRANSIENT RESPONSE TO STEP AND PULSE FUNCTIONS., Hoppman, W. K., Chap. 9, Vol. I, EFFECTS OF IMPACT ON STRUCTURES, McGraw-Hill Publishers, New York, 1961.

9. Timoshenko, S., and Woinowsky-Krieger, S., THEORY OF PLATES AND SHELLS, McGraw-Hill Publishers, New York, 1959.

10. Tulk, F. D., BUCKLING OF CIRCULAR CYLINDRICAL SHELLS UNDER DYNAMICALLY APPLIED AXIAL LOADS, UTIAS Report 160, 1972.

11. Striklin, J. E., et al, LARGE DEFLECTION ELASTIC-PLASTIC DYNAMIC RESPONSE OF STIFFENED SHELLS OF REVOLUTION, TEES-RPT-72-25 and SLA-73-0128, 1972.

12. Becker, H., Gerard, G., HANDBOOKS OF STRUCTURAL STABILITY, PARTS I - V. NACA Technical Notes, TN 3781 - 3785, 1957.

13. Skogh, J., and Stern, P., POSTBUCKLING BEHAVIOR OF A SECTION REPRESENTATIVE OF THE B-1 AFT INTERMEDIATE FUSELAGE, Lockheed Palo Alto Research, AFFDL-TR-73-63, Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, May 1973.

14. Atluri, S., PETROS 3: A FINITE-DIFFERENCE METHOD AND PROGRAM FOR THE CALCULATION OF LARGE ELASTIC-PLASTIC DYNAMICALLY-INDUCED DEFORMATIONS OF MULTILAYER VARIABLE THICKNESS SHELLS, BRL, U. S. Army Aberdeen Research and Development Center, Aberdeen Proving Ground, Maryland, Contract #DAAD05-68-C-0314, Nov. 1971.

15. Haftka, R. T., A KOITER-TYPE METHOD FOR FINITE ELEMENT ANALYSIS OF NON-LINEAR STRUCTURAL BEHAVIOR, AFFDL-TR-70-130, Vol. I, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, Nov. 1970.

16. Stilwell, W. C., and Ball, R. E., A DIGITAL COMPUTER STUDY OF THE BUCKLING OF SHALLOW SPHERICAL CAPS AND TRUNCATED HEMISPHERES, NASA CR 1998, June 1972.

17. Witmer, E. A., LARGE DYNAMIC DEFORMATIONS OF BEAMS, RINGS, PLATES AND SHELLS, AIAA Journal, Vol. I, No. 2, August 1963.

18. Perrone, N., ON A SIMPLIFIED METHOD FOR SOLVING IMPULSIVELY LOADED STRUCTURES OF RATE-SENSITIVE MATERIALS, Office of Naval Research, Wash., D. C., Journal of Applied Mechanics, ASME, September 1965.

19. Bodner, S. R., and Symonds, P. S., EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE PLASTIC DEFORMATION OF CANTILEVER BEAMS SUBJECTED TO IMPULSIVE LOADING, Brown University, Journal of Applied Mechanics, December 1962.

20. Hibbit, H. D., et al, A FINITE ELEMENT FORMULATION FOR PROBLEMS OF LARGE STRAIN AND DISPLACEMENT, Brown University, International Journal of Solids and Structures, 1970, Vol. 6, pp. 1069-1086.

21. Toridio, T. G., and Khozeimeh, K., INELASTIC RESPONSE OF FRAMES TO DYNAMIC LOADS, A.S.C.E. Proceedings, Engineering Mechanics Division, June 1971.

22. McDaniel, T. J., DYNAMICS OF STIFFENED CYLINDRICAL SHELLS WITH SPATIALLY VARYING CURVATURE, University of Dayton Research Institute, Air Force Materials Laboratory Report AFML-TR-72-134, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, July 1972.

23. Bendix Corp., Final Engineering Report, ENERGY ABSORBING CHARACTERISTICS OF CRUSHABLE ALUMINUM STRUCTURES IN A SPACE ENVIRONMENT, NASA-CR-65096, July 1965.

24. Kornhauser, M., STRUCTURAL EFFECTS OF IMPACT, Sparton Books, Inc., Baltimore, Md. 1964.

25. Fisher, L. J., Jr., LANDING-IMPACT-DISSIPATION SYSTEMS, NASA Technical Note D-975, December 1961.

26. McGehee, J. R., A PRELIMINARY EXPERIMENTAL INVESTIGATION OF AN ENERGY-ABSORPTION PROCESS EMPLOYING FRANGIBLE METAL TUBING, NASA Technical Note D-1477, 1962.

27. Kroell, C. K., A SIMPLE, EFFICIENT, ONE SHOT ENERGY ABSORBER, General Motors Research Laboratory, Warren, Michigan, Shock, Vibration and Associated Environments, Part III, Bulletin No. 30, 1962.

28. Weinberg, L. W. T., and Turnbow, J. W., Ph.D., SURVIVABILITY SEAT DESIGN DYNAMIC TEST PROGRAM, Aviation Safety Engineering and Research USAAVLABS Technical Report 65-43, U.S. Army Aviation Materiel Laboratories, Ft. Eustis, Virginia, July, 1965, AD 621718.

29. Langhaar, H. L., THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THIN-WEBBED PLATE-GRIDER BEAMS, Transactions of ASME, October 1943.

30. Perry, D. J., AIRCRAFT STRUCTURES, McGraw-Hill Book Co., New York, 1950.

31. Jones, N., et al, THE DYNAMIC PLASTIC BEHAVIOR OF SHELLS, MIT Report 71-6, 1971.

32. Mitchell, B., THE DYNASORB ENERGY ABSORBER, Lockheed Report LR 16735, March 1963.

33. Mitchell, B., SHOCK ABSORPTION WITH ONE SHOT TUBES, Lockheed Report LR 16369, June 1963.

34. Mitchell, B., DESIGN NOTES FOR THE DYNASORB ENERGY ABSORBER, Lockheed Report LR 17201, December 1963.

35. Mitchell, B., ENERGY ABSORPTION AT HIGH SPEED VERTICAL LANDING, Lockheed Report LR 21023, November 1967.

36. Perrone, N., RESPONSE OF RATE SENSITIVE FRAMES TO IMPULSIVE LOAD, ASME Journal of Applied Mechanics, February 1971, pp. 49-62.

37. Jones, Norman, INFLUENCE OF STRAIN-HARDENING AND STRAIN-RATE SENSITIVITY ON THE PERMANENT DEFORMATION OF IMPULSIVELY LOADED RIGID PLASTIC BEAMS, International Journal of Mechanical Science, 1967 Vol. 9, pp. 777-796.

38. Ni, C. M., IMPACT RESPONSE OF CURVED BOX BEAM-COLUMNS WITH LARGE GLOBAL AND LOCAL DEFORMATIONS, Research Laboratories, General Motors Corp., Warren, Michigan, AIAA Paper 73-401.

39. O'Bryan, T. C., and Hatch, H. G., Jr., LIMITED INVESTIGATION OF CRUSHABLE STRUCTURES FOR ACCELERATION PROTECTION OF OCCUPANTS OF VEHICLES AT LOW IMPACT SPEEDS, NASA Technical Note D-158, 1958.

40. Jones, Norman, THE INFLUENCE OF LARGE DEFLECTION ON THE BEHAVIOR OF RAPID-PLASTIC CYLINDRICAL SHELLS LOADED IMPULSIVELY, Journal of Applied Mechanics, ASME June 1970, pp. 417-425.

41. D'Amato, R., STATIC POST-FAILURE STRUCTURAL CHARACTERISTICS OF MULTI-WEB BEAMS, WADC TR 59-112, February 1959.

42. Rawlings, B., ENERGY ABSORPTION OF DYNAMICALLY AND STATICALLY TESTED MILD STEEL BEAMS UNDER CONDITIONS OF GROSS DEFORMATION, International Journal of Mechanical Sciences, Pergamon Press, Ltd., 1967, Vol. 9, pp. 633-649, Printed in Great Britain.

43. Thompson, J. E., VEHICLE CRUSH PREDICTION USING FINITE-ELEMENT TECHNIQUES, Chrysler Corp., SAE Paper 73-157, January 1973.

44. Burgmann, J. B., and Rawlings, B., DYNAMIC PLASTIC ANALYSIS OF PIN-JOINTED FRAMES, International Journal of Mechanical Science, Pergamon Press, 1968, Vol. 10, pp. 967-980, Printed in Great Britain. (Received 8 May 1968, and in revised form 30 July 1968).

45. Martin, J. B., MODE APPROXIMATION FOR IMPULSIVELY LOADED STRUCTURES IN THE INELASTIC RANGE, Proceedings of the Southampton 1969 Civil Engineering Material Conference.

46. Jensen, W. R., Falby, W. E., and Prince, N., MATRIX ANALYSIS METHODS FOR ANISTROPIC INELASTIC STRUCTURES, AFFDL-TR-65-220, April 1966.

47. Isaakson, G., Armen, H., Jr., and Pipko, A., DISCRETE ELEMENT METHODS FOR THE PLASTIC ANALYSIS OF STRUCTURES, NASA CR 803, October 1967.

48. Stricklin, J. A., et al, NONLINEAR DYNAMIC ANALYSIS OF SHELLS OF REVOLUTION BY MATRIX DISPLACEMENT METHOD, AIAA Journal, Vol. 9, No. 4, April 1971, p. 629.

49. Owens, R. H., and Symonds, P. A., PLASTIC DEFORMATION OF A FREE RING UNDER CONCENTRATED DYNAMIC LOADING, ASME Journal of Applied Mechanics, December 1955, p. 524.

50. Lee, H., and Symonds, P. S., LARGE PLASTIC DEFORMATIONS OF BEAM UNDER TRANSVERSE IMPACT, ASME Journal of Applied Mechanics, September 1952, p. 308.

51. Prager, W., A NEW METHOD OF ANALYZING STRESSES AND STRAINS IN WORK-HARDENING PLASTIC SOLIDS, ASME Journal of Applied Mechanics, December 1956, p. 493.

52. Morino, L., Leach, J. W., and Witmer, E. A., AN IMPROVED NUMERICAL CALCULATION TECHNIQUE FOR LARGE ELASTIC-PLASTIC TRANSIENT DEFORMATIONS OF THIN SHELLS, Part 1, ASME Journal of Applied Mechanics, June 1971, p. 423.

53. Pifko, A. Isaakson, A FINITE-ELEMENT METHOD FOR THE PLASTIC BUCKLING ANALYSIS OF PLATES, Grumman Aerospace Corporation, Bethpage, N. Y., AIAA Journal, Vol. 7, No. 10, October 1969.

54. Armen, H., Jr., Pifko, A., and Levine, H. S., FINITE ELEMENT ANALYSIS OF STRUCTURES IN THE PLASTIC RANGE, NASA CR 1649, February 1971.

55. Mallett, R. H., AUTOMATED METHOD FOR THE LARGE DEFLECTION AND INSTABILITY ANALYSIS OF THREE-DIMENSIONAL TRUSS AND FRAME ASSEMBLIES, AFFDL-TR-66-102, December 1966.

56. Przemieniecki, J. S., MATRIX METHODS IN STRUCTURAL MECHANICS, AFFDL-TR-66-80, Conference held October 26-28, 1965.

57. Berke, L., PROCEEDINGS OF THE SECOND CONFERENCE ON MATRIX METHODS IN STRUCTURAL MECHANICS, AFFDL-TR-68-150, Conference held 15-17 October 1968.

58. Symonds, P. S., SURVEY OF METHODS OF ANALYSIS FOR PLASTIC DEFORMATION OF STRUCTURES UNDER DYNAMIC LOADING, BU/NSRDC/1-67, Brown University, Providence, R. I., 1967.

59. Semonian, J. W., and Anderson, R. A., AN ANALYSIS OF THE STABILITY AND ULTIMATE BENDING STRENGTH OF MULTIWEB BEAMS WITH FORMED CHANNEL WEBS, NACA Technical Note TN 3232, 1954.

60. Semonian, J. W., and Peterson, J. P., AN ANALYSIS OF THE STABILITY AND ULTIMATE COMPRESSIVE STRENGTH OF SHORT SHEET STRINGER PANELS WITH SPECIAL REFERENCE TO THE INFLUENCE OF THE RIVETED CONNECTION BETWEEN SHEET STRINGERS, NACA Technical Report TR 1255, 1956.

61. Bleich, F., BUCKLING STRENGTH OF METAL STRUCTURES, McGraw-Hill Publishers, New York, 1952.

62. Newmark, N. M., A METHOD OF COMPUTATION FOR STRUCTURAL DYNAMICS, A.S.C.E. Proceedings, Engineering Mechanics Divisions, Vol. 85, EM-3, pp. 67-94, 1959.

63. Bushnell, D., et al, FINITE-DIFFERENCE ENERGY METHOD FOR NONLINEAR SHELL ANALYSIS, Journal of Computer & Structures, Vol. 1, 1971, pp. 361-387.

64. Koiter, W. T., Ph.D. Thesis, NASA TTF-10, 883, 1967, WPAFB, AFFDL-TR-70-25, 1970.

65. Sewell, M. J., A GENERAL THEORY OF EQUILIBRIUM PATHS THROUGH CRITICAL POINTS, Royal Society Proceedings, Series A, 306, pp. 201-223, 1968.

66. Tong, P., A NOTE ON POST-BUCKLING SOLUTION OF ELASTIC STRUCTURES, ASRL-TR 1444-4, MIT, January 1970.

67. Chu, K. H., and Gonwens, A. J., ELASTIC BUCKLING OF BEAM FLANGE PLATES, EM-4, ASCE, pp. 1324-1336, August 1971.

68. El-Bayoumy, L., BUCKLING OF CLAMPED RECTANGULAR PLATES, ASCE, EM-4, pp. 1277-1288, August 1971.

69. Stein, M., THE PHENOMENON OF CHANGE IN BUCKLE PATTERN IN ELASTIC STRUCTURES, NASA Technical Note TN R-39, 1959.

70. Rhodes, J., and Harvey, J. M., THE LOCAL BUCKLING AND POST-LOCAL BUCKLING BEHAVIOR OF THIN-WALLED BEAMS, Aeronautical Quarterly, 22, 4, pp. 363-388, November 1971.

71. Rhodes, J., THE POST-BUCKLING BEHAVIOR OF THIN FLAT PLATES IN COMPRESSION WITH UNLOADED EDGES ELASTICALLY RESTRAINED AGAINST ROTATION, Journal of Mechanical Engineering Sciences, 13, 2, pp. 82-91, April 1971.

72. Graves, A., Smith, T. R., THE EFFECT OF INITIAL IMPERFECTIONS ON THE STRENGTH OF THIN WALLED BOX COLUMNS, International Journal of Mechanical Sciences, 13, 11, pp. 911-925, November 1971.

73. Hutchinson, S. W., and Koiter, W. T., POST-BUCKLING THEORY, Applied Mechanics Reviews, December 1970.

74. Sewell, M. J., A GENERAL THEORY OF EQUILIBRIUM PATHS THROUGH CRITICAL POINTS, Proceedings of Royal Society, Series A, 306, pp. 201-223, 1968.

75. Cox, H. L., THE BUCKLING OF PLATES AND SHELLS, The MacMillan Company, N. Y., 1963.

76. Chitner, A. H., THIN-WALLED STRUCTURES, John & Wiley & Sons, Inc., New York, 1967.

77. Mau, S. T., and Gallagher, R. H., A FINITE ELEMENT PROCEDURE FOR NON-LINEAR PRE-BUCKLING AND INITIAL POST-BUCKLING ANALYSIS, NASA CR-1936, January 1972.

78. Vos, Robert F., FINITE ELEMENT ANALYSIS OF PLATE BUCKLING AND POST-BUCKLING, Ph.D. Thesis, Rice University, Houston, Texas, 1970.

79. Roberts, T. M., and Ashwell, D. G., THE USE OF FINITE ELEMENT MID-INCREMENT STIFFNESS MATRICES IN THE POST-BUCKLING ANALYSIS OF IMPERFECT STRUCTURES, Journal of Solids and Structures, 7.7, pp. 805-823, July 1971.

80. Greer, D. L., et al, CRASHWORTHY DESIGN PROCEDURES, General Dynamics, CONVAIR, FAA Technical Report ADS-24, Federal Aviation Administration, Washington, D. C., November 1965, AD 623575.

81. Stein, M., LOADS AND DEFORMATIONS OF BUCKLED RECTANGULAR PLATES, NACA Technical Report, TR-R-40, 1959, Washington, D. C.

82. Gatlin, Clifford I., et al, ANALYSIS OF HELICOPTER STRUCTURAL CRASHWORTHINESS, Dynamic Science, USAAVLABS Technical Report 70-71, 71B, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Ft. Eustis, Virginia, January 1971, AD880680.

83. Sechler, E. E., and Dunn, L. G., AIRPLANE STRUCTURAL ANALYSIS AND DESIGN, Dover Publishers Inc., 1963, New York, N. Y.

84. Hutchinson, J. W., and Budiansky, B., DYNAMIC BUCKLING ESTIMATES, AIAA Journal 4, pp. 525-530, 1966.

85. Thompson, J.M.T., DYNAMIC BUCKLING UNDER STEP LOADING, IN DYNAMIC STABILITY OF STRUCTURES (Ed. by G. Herrmann), Pergamon Press, 1965.

86. Budiansky, B., DYNAMIC BUCKLING OF ELASTIC STRUCTURES. CRITERIA AND ESTIMATES IN DYNAMIC STABILITY AND STRUCTURES (Ed. by G. Herrmann), Pergamon Press, 1965.

87. Mayer, J., and Budiansky, B., ANALYSIS OF BEHAVIOR OF SIMPLY SUPPORTED FLAT PLATES COMPRESSED BEYOND THE BUCKLING LOAD INTO THE PLASTIC RANGE, NACA TN 3368, Washington, D. C., 1955.

88. Walker, A. C., FLAT RECTANGULAR PLATES SUBJECTED TO LINEARLY-VARYING EDGE COMPRESSIVE LOADING, in Thin-Walled Structures (Ed. by A. H. Chilner), John Wiley & Sons, Inc., New York, 1967.

89. Walker, A. C., THE POST-BUCKLING BEHAVIOR OF SIMPLY SUPPORTED SQUARE PLATES, Aero. Quarterly, Vol. XX, August 1, 1969, pp. 203-222.

90. Masur, E. F., BUCKLING, POST-BUCKLING AND LIMIT ANALYSIS OF COMPLETELY SYMMETRIC ELASTIC STRUCTURES, International Journal of Solids and Structures, 1970, Vol. 6, pp. 587-604.

91. Hutchinson, J. W., and Koiter, W. T., POST-BUCKLING THEORY, Applied Mechanics Review, December 1970, pp. 1353-1366.

92. Needham, R. A., THE ULTIMATE STRENGTH OF ALUMINUM ALLOY FORMED STRUCTURAL SHAPES IN COMPRESSION, Journal of Aeronautical Sciences, Vol. 21, No. [illegible], 1954, pp. 217-229.

93. Schuette, E. H., OBSERVATIONS OF THE MAXIMUM AVERAGE STRESS OF FLAT PLATES BUCKLED IN EDGE COMPRESSION, NACA TN 1625, 1949.

94. Semonian, J. W., and Peterson, J. P., AN ANALYSIS OF THE STABILITY AND ULTIMATE COMPRESSIVE STRENGTH OF SHORT SHEET-STRINGER PANELS WITH SPECIAL REFERENCE TO THE INFLUENCE OF RIVETED CONNECTION BETWEEN SHEET AND STRINGER, NACA Report 1255, 1956.

95. Stowell, E., A UNIFIED THEORY OF PLASTIC BUCKLING OF COLUMNS AND PLATES, NACA Report 898, 1947.

96. Dow, N. F., and Hickman, W. A., EFFECT OF VARIATION IN RIVET DIAMETER AND PITCH ON THE AVERAGE STRESS AT MAXIMUM LOAD FOR 24S-T3 AND 75S-T6 ALUMINUM-ALLOY, FLAT, Z-STIFFENED PANELS THAT FAIL BY LOCAL INSTABILITY, NACA TN 2139, 1950.

97. Dow, N. F., Hickman, W. A., and Rosen, B. W., EFFECT OF VARIATION IN RIVET STRENGTH ON THE AVERAGE STRESS AT MAXIMUM LOAD FOR ALUMINUM-ALLOY, FLAT, Z-STIFFENED COMPRESSION PANELS THAT FAIL BY LOCAL BUCKLING, NACA TN 2963, 1953.

98. Von Karman, T. L., Sechler, E. E., and Donnel, L. H., THE STRENGTH OF THIN PLATES IN COMPRESSION, Journal of Applied Mechanics Transcripts, A.S.M.E., Vol. 54, No. 2, 1932.

99. Marguerre, K., THE APPARENT WIDTH OF THE PLATE IN COMPRESSION, NACA Technical Memo 933, 1937.

100. Timoshenko, S. P., and Gere, J. M., THEORY OF ELASTIC STABILITY, 2nd Ed., McGraw-Hill Book Co., New York, 1961.

101. Neal, B. G., THE EFFECT OF SHEAR AND NORMAL FORCES ON THE FULLY PLASTIC MOMENT OF A BEAM OF RECTANGULAR CROSS-SECTION, Journal of Applied Mechanics, Vol. 28, 1961, pp. 269-274.

102. Vlasov, V. Z., THIN-WALLED ELASTIC BEAMS, English Translation by National Science Foundation, Second Ed., pp. 286-288, 335-368.

103. Hodge, P. H., Jr., PLASTIC ANALYSIS OF STRUCTURES, McGraw-Hill Book Co., New York, 1959.

104. Neal, B. G., THE PLASTIC METHODS OF STRUCTURAL ANALYSIS, Chapman & Hall, London, 1956.

105. Heimerl, G. J., and Woods, W., EFFECT OF BRAKE FORMING ON THE STRENGTH OF 23S-TITANIUM ALLOY SHEET, NACA Technical Note TN 1072, May 1946.

106. Haley, J., PRELIMINARY DRAFT, COST EFFECTIVENESS OF CRASHWORTHY STRUCTURAL FEATURES IN A 9-13 PLACE HELICOPTER, USAAVS Technical Report 72-1, U. S. Army Agency for Aviation Safety, Ft. Rucker, Alabama, 1972.

107. Walker, A. C., THE POST-BUCKLING BEHAVIOR OF SIMPLY-SUPPORTED SQUARE PLATES, The Aeronautical Quarterly, Vol. XX, 1969, pp. 203-222.

108. Kuhn, P., Petterson, J. P., and Levin, L. R., A SUMMARY OF DIAGONAL TENSION, PART I - METHODS OF ANALYSIS, NACA TN 2661, 1952, Washington, D. C., p. 32.

109. Lowe, W. T., et al, IMPACT BEHAVIOR OF SMALL SCALE MODEL MOTOR COACHES, Proceedings of the Institute of Mechanical Engineers, Vol. 186, No. 36, 1972, pp. 409-419.

110. Saczalski, K. J., and Park, K. C., AN INTERACTIVE HYBRID TECHNIQUE FOR CRASHWORTHY DESIGN OF COMPLEX VEHICLE STRUCTURAL SYSTEMS, To be presented at S.A.E. International Conference of Vehicle Structural Mechanics, Detroit, Michigan, March 26-28, 1974.

111. Hone, C. P., TORSIONAL-FLEXURAL BUCKLING OF AXIALLY-LOADED, THIN-WALLED, ELASTIC STRUTS OF OPEN CROSS-SECTION IN THIN-WALLED STRUCTURES, (Ed. by A. H. Chilver), John Wiley & Sons, Inc., New York, 1967.

112. ENGINEERING DATA, HEXCELL TECHNICAL SERVICE BULLETINS, TB 110 through TB 123, 1960 - 1968, Hexcell Products Inc., Berkeley, California.

LIST OF SYMBOLS

SUBSTRUCTURE ANALYSIS

A	area; for stiffened panel, area of stiffener plus area of sheet corresponding to stiffener spacing, $in.^2$
a	plate length, in.
A_s	area of stiffener, $in.^2$
A_w	area of web, $in.^2$
b_s	width of skin, in.
b_w	width of stiffener web, in.
C	constant (= 3.0)
c	number of cuts
d	rivet diameter, in.
E	modulus of elasticity, psi
e, e_o	distance to neutral axis, in.
f	number of flanges
f_{cr}	crush strength, lb
f_w	effective rivet off-set, in.
G	acceleration level
g	gravity term = 386.2 $in./sec^2$
H	distance, in.
I	moment of inertia, $in.^4$
I_o	moment of inertia about c.g., $in.^4$
K	eccentricity factor
KE	kinetic energy, in.-lb
K_w	wrinkling coefficient
L, ℓ	one-half column length, in.
L'	effective length $= L/\sqrt{C}$, in.
M	effective moment, in.-lb

M_p	plastic hinge moment, in.-lb
N/A	neutral axis
N	effective axial force, lb
N_p	plastic hinge axial force, lb.
p	rivet pitch, in.
P	applied axial force, lb
P_f	monolithic failure load, lb
P_{f_w}	wrinkling failure load, lb
q	distributed load, lb/in.
S	stopping distance, core radius of given cross section, in.
s	distance from midcross-section of skin to neutral axis of stiffener, in.
T	ratio of σ/σ_{cy}
T_{cr}	ratio of critical stress (σ_{cr}) to yield stress (σ_{cy})
t_c	minimum core thickness, in.
t_s	skin thickness, in.
$\bar{t}_w$	stiffener thickness, in.
V	impact velocity, in./sec
W	weight, lb
w_e	effective half width of skin, in.
y	lateral deflection
Z	function of column length and end shortening, in.
α	defined in equation 51
η	plasticity reduction factor
$\bar{\eta}$	cladding reduction factor
π	P_i = 3.14
θ	$\tan^{-1} Z$
ρ	radius of gyration $= \sqrt{I/A}$, in.
γ	partial derivative

SUBSTRUCTURE ANALYSIS (Continued)

δu	incremental displacement
δ, Δ, u	displacement, end shortening
ν	Poisson's ratio
x	distance to c.g., in.
σ	compressive stress, psi
σ_b	stress at outermost fiber of sheet skin, psi
σ_{co}	column buckling stress, psi
σ_{cr}	buckling stress, psi
σ_{cy}	compressive yield stress, psi
$\bar{\sigma}_{cy}$	effective compressive yield stress, psi
σ_{cy_w}	effective compressive yield stress for stiffener web, psi
σ_{cy_s}	effective compressive yield stress for skin, psi
σ_e	Euler stress, psi
σ_f	crippling (or failure) stress, psi
σ_{fr}	failure stress of riveted panel, psi
σ_w	failure stress due to wrinkling mode, psi
σ_{zo}	buckling stress at $L'/\rho = 20$

Subscripts:

b	bending
f	filler
i	i^{th} segment
max.	maximum
min.	minimum
p	plastic state
s	skin or sheet
w	stiffener web

Constants (function of stiffened panel configuration)

β_f

β_g

g

m

n

PROGRAM "KRASH"

$\left[A_i\right]$	rotational transformation matrix from body axes to ground axes
$\left[A_i\right]^T$	transpose of A_i matrix
CE	total crash spring (external spring) energy absorbed
DE	total damping energy dissipated
DRI	dynamic response index
E_{TOT}	total system energy
$FD_{ij\ell}$	internal beam damping force (or moment) for the ij^{th} beam in the ℓ^{th} direction
FSP_{ijk}	crash spring forces; spring ij in the k^{th} direction
$F_{ij\ell}$	force (or moment) at point j due to beam ij, in the ℓ^{th} direction
I_{xi}, I_{yi}, I_{zi}	moments of inertia of lumped mass m_i about i^{th} body fixed axes
I_{xyi}, I_{yzi}, I_{zxi}	product of inertia of lumped mass m_i about i^{th} body axes
KE	total kinetic energy
ℓ_{ik}	length of vector from m_i to ground contact point C'_{ik}
m_i	i^{th} lumped mass
N	number of lumped masses
PE	total potential energy
SE	total strain energy absorbed
$TERM_{ij}$	term in expression for crash spring energy

PROGRAM "KRASH" (Continued)

W_i	weight of i^{th} lumped mass
x_i, y_i, z_i	ground coordinates of m_i
u_i, v_i, w_i	i^{th} body axes component of absolute translational velocity vector of mass i
p_i, q_i, r_i	i^{th} body axes components of absolute angular velocity vector of mass i
$\begin{Bmatrix} X_{ci}, Y_{ci}, Z_{ci} \\ L_{ci}, M_{ci}, N_{ci} \end{Bmatrix}$	crash (external) forces and moments, i^{th} body axes
$\Delta x_i'$, $\Delta y_i'$, $\Delta z_i'$	$= \{\Delta vc_i\}$, incremental displacement of point i, i^{th} body axes
Δinp_i, Δinq_i, Δinr_i	incremental rotation of point i, i^{th} body axes
$\Delta vb_{ij\ell}$	incremental displacement vector of point j with respect to point i, due to deformation of beam ij, in the ℓ^{th} direction

USER'S GUIDE AND REFERENCE 1 TERMS

A_i, B_i, C_i	Terms used in Euler's equations of motion
$[A_i]$	Rotation transformation matrix from body axes to ground axes
$[\bar{A}_i]$	Matrix relating $(\dot{\phi}_i, \dot{\theta}_i, \dot{\psi}_i)$ to (p_i, q_i, r_i) in equation (92)
$[\dot{A}_i]$	Time derivative of $[A_i]$
$[A_i'']$	Rotation transformation matrix from ith body axes to c.g. axes
$[A_{ij}]$	Rotation transformation matrix from beam ij axes to body i axes
$[A']$	Rotation transformation matrix from c.g. axes to ground axes
$[\bar{A}']$	Matrix relating $(\dot{\phi}', \dot{\theta}', \dot{\psi}')$ to (p', q', r') in equation (88)
C_{ik}	End point of kth spring on ith mass
C_{ik}'	Ground contact point of kth spring on ith mass
dvc_{ijk}	Ground axes components of vector from m_i to C_{ik}
dvc_{ijk}'	Ground axes components of vector for C_{ik}' to C_{ik}
$[D_i]$	Derivative matrix
$[D']$	Derivative matrix
FM_{ijkl}	Running time sum of ΔFM_{ijkl}
$\overline{FM}_{ijkl}$	Value of FM_{ijkl} at time of loading reversal
FSP_{ijk}	Body i axes components of spring force at ground contact point C_{ik}'
$FSPO_{ik}$	Axial compressive force in kth spring on ith mass
$\overline{FSPO}_{ik}$	Value of $FSPO_{ik}$ at time of loading reversal

USER'S GUIDE AND REFERENCE 1 TERMS

$FSPO_{Fik}$	Final value of $FSPO_{ik}$ in input table of s_{ik} vs. $FSPO_{ik}$
G	Center-of-gravity of total vehicle
H	Origin of helicopter coordinate system (F.S.0, B.L.0, W.L.0)
He_{xi}, He_{yi}, He_{zi}	Angular momenta of mi due to rotation of masses internal to m_i
I_{xi}, I_{yi}, I_{zi}	Moments of inertia of lumped mass mi, about ith body fixed axes
I_{xyi}, I_{yzi}, I_{zxi}	Products of inertia of lumped mass m_i, about ith body fixed axes
ke_{ik}	Linear unloading stiffness for kth spring
$[K_{ij}]$	Six by six linear stiffness matrix for beam ij
$[KR_{ij}]$	Six by six diagonal stiffness reduction matrix for beam ij
l_{ik}	Length of vector from m_i to ground contact point C'_{ik}
$\bar{l}_{xi}$, $\bar{l}_{yi}$, $\bar{l}_{zi}(\bar{l}_{ik})$	Free length of kth spring on ith mass
l_{ci}	Aerodynamic lift constant
$LIFT_i$	Aerodynamic lift on m_i, positive up, in ground axes
m_i	ith lumped mass
mu_{ik}	Ground-spring friction coefficient for kth spring on ith mass
N	Total number of lumped masses
$\bar{n}_{ik}$	Unit vector triad fixed in ith body coordinate system
$\bar{n}_x$, $\bar{n}_y$, $\bar{n}_z$	Unit vector triad fixed in ground coordinate system
O	Origin of ground coordinate system

USER'S GUIDE AND REFERENCE 1 TERMS

p_i, q_i, r_i	ith body axes components of absolute angular velocity vector of mass i
p', q', r'	c.g. axes components of initial(t=0) vehicle angular velocity vector
$[pl_i]$	Contact point velocity matrix used in equation (60)
s_{ik}	Axial external spring compression, kth spring on ith mass
$\bar{s}_{ik}$	Value of s_{ik} at time of loading reversal
sF_{ik}	Final value of s_{ik} in input table of s_{ik} vs. $FSPO_{ik}$
s'_{ik}	kth spring axial compression measured relative to current load stroke curve origin
s''_{ik}	Horizontal shift of s'_{ik} coordinates with respect to S_{ik} coordinates
t	Time
$[T_{ij}]$	Static balance matrix used in equation (30b)
u_i, v_i, w_i	Body i axes components of absolute translational velocity vector of point m_i
va_{ij}	x_i, y_i, z_i
vb_{ij}	Running time sum of Δvb_{ij}
$\overline{vb}_{ijl}$	Value of vb_{ijl} at time of loading reversal
$\bar{v}_{ik}$	Magnitude of ground plane contact point velocity
vb'_{ijl}	lth total beam deflection measured relative to current load-stroke curve origin
vb''_{ijl}	Horizontal shift of vb'_{ijl} coordinates with respect to vb_{ijl} coordinates
vc_{ijk}	Ground coordinates of point C_{ik}

$\dot{vcp}_{ijk}$	Ground axes components of absolute velocity of ground contact point C'_{ik}
${}^{m_i}\vec{V}^{c'}$	Velocity vector of C'_{ik} with respect to m_i
${}^{o}\vec{V}^{c'}$	Velocity vector of C'_{ik} with respect to ground
${}^{o}\vec{V}^{m_i}$	Velocity vector of m_i with respect to ground
W_i	Weight of ith lumped mass
W_{TOT}	Total vehicle weight
$xb_{ij}, yb_{ij}, zb_{ij}$	Beam ij coordinates
x_G, y_G, z_G (vg_j)	Ground coordinates of initial (t = o) c.g. position
$\dot{x}_G, \dot{y}_G, \dot{z}_G$	Ground axes components of initial (t = o) c.g. velocity vector
x''_G, y''_G, z''_G $(vgpp_{ij})$	Helicopter axes coordinates of vehicle c.g. (point G)
x_i, y_i, z_i (va_{ij})	Ground coordinates of m_i
x'_i, y'_i, z'_i (vip_{ij})	Coordinates of m_i in center-of-gravity coordinate system
x''_i, y''_i, z''_i $(vipp_{ij})$	Coordinates of m_i in helicopter coordinate system
x_{ij}, y_{ij}, z_{ij}	Ground coordinates of vector from point i to point j
$x'_{ij}, y'_{ij}, z'_{ij}$	ith body coordinates of vector from point i to point j
$\begin{pmatrix} X'_{ij}, & Y'_{ij}, & Z'_{ij} \\ L'_{ij}, & M'_{ij}, & N'_{ij} \end{pmatrix}$	Total (summed over time) internal forces and moments at point i due to beam ij, i^{th} body axes
$\begin{pmatrix} X'_{ji}, & Y'_{ji}, & Z'_{ji} \\ L'_{ji}, & M'_{ji}, & N'_{ji} \end{pmatrix}$	Total (summed over time) internal forces and moments at point j due to beam ij, j^{th} body axes

USER'S GUIDE AND REFERENCE 1 TERMS

$\begin{pmatrix} X_i, & Y_i, & Z_i \\ L_i, & M_i, & N_i \end{pmatrix}$	Total forces and moments on mass i, in ith body axes
X_{Ai}, Y_{Ai}, Z_{Ai}	Aerodynamic forces, i^{th} body axes
$\begin{pmatrix} X_{Ci}, & Y_{Ci}, & Z_{Ci} \\ L_{Ci}, & M_{Ci}, & N_{Ci} \end{pmatrix}$	Crash (external) forces and moments, i^{th} body axes
X_{Gi}, Y_{Gi}, Z_{Gi}	Gravity forces, i^{th} body axes
$\begin{pmatrix} X_{Ii}, & Y_{Ii}, & Z_{Ii} \\ L_{Ii}, & M_{Ii}, & N_{Ii} \end{pmatrix}$	Internal forces and moments, i^{th} body axes
$XVOC_{ijk}$	Ground axes components of spring force at ground contact point C'_{ik}, positive up, left and aft
zc_{MAX}	Vertical distance from c.g. to lowest C'_{ik}
Δi	Determinate expression used in equation (68)
ΔF_{ijk}	Incremental forces and moments at point j due to beam ij
ΔFM_{ijkl}	kth incremental load due to lth incremental deflection for beam ij
$\Delta\phi b_{ij}$, $\Delta\theta b_{ij}$, $\Delta\psi b_{ij}$	Incremental rotations of point j with respect to point i, in beam ij axes
$\Delta\phi_i$, $\Delta\theta_i$, $\Delta\psi_i$	Incremental change in ith mass Euler angles
Δt	Numerical integration time interval
Δvb_{ij}	Six element vector made up of Δxb_{ij}, Δyb_{ij}, Δzb_{ij}, $\Delta\phi b_{ij}$, $\Delta\theta b_{ij}$, $\Delta\psi b_{ij}$
$\overrightarrow{\Delta vb_{ij}}$	Incremental displacement vector of point j with respect to point i, due to deformation of beam ij
$\overrightarrow{\Delta vd_{ij}}$	Incremental displacement vector of point j with respect to point i

USER'S GUIDE AND REFERENCE 1 TERMS

$\overrightarrow{\Delta vr}_{ij}$	Incremental displacement vector of point j with respect to point i, due to rotation of mass i
$\Delta xb_{ij}, \Delta yb_{ij}, \Delta zb_{ij}$	Coordinates of $\overrightarrow{\Delta vb}_{ij}$ in beam ij axes
$\Delta x_i, \Delta y_i, \Delta z_i$	Incremental displacement of point i, ground axes
$\Delta x_{ij}, \Delta y_{ij}, \Delta z_{ij}$	Incremental displacement of point j with respect to point i in ground axes
$\begin{pmatrix} \Delta X_{ij}, \Delta Y_{ij}, \Delta Z_{ij} \\ \Delta L_{ij}, \Delta M_{ij}, \Delta N_{ij} \end{pmatrix}$	Incremental internal forces and moments at point j due to beam ij, in beam ij axes (elements of ΔF_{ij} vector)
$\begin{pmatrix} \Delta X^o_{ij}, \Delta Y^o_{ij}, \Delta Z^o_{ij} \\ \Delta L^o_{ij}, \Delta M^o_{ij}, \Delta N^o_{ij} \end{pmatrix}$	Incremental internal forces and moments at point j due to beam ij, ground axes
$\begin{pmatrix} \overline{\Delta X^o_{ij}}, \overline{\Delta Y^o_{ij}}, \overline{\Delta Z^o_{ij}} \\ \overline{\Delta L^o_{ij}} \; \overline{\Delta M^o_{ij}} \; \overline{\Delta N^o_{ij}} \end{pmatrix}$	Incremental internal forces and moments at point i due to beam ij ,ground axes
$\begin{pmatrix} \Delta X'_{ij}, \Delta Y'_{ij}, \Delta Z'_{ij} \\ \Delta L'_{ij}, \Delta M'_{ij}, \Delta N'_{ij} \end{pmatrix}$	Incremental internal forces and moments at point i due to beam ij, i^{th} body axes
$\begin{pmatrix} \Delta X'_{ji}, \Delta Y'_{ji}, \Delta Z'_{ji} \\ \Delta L'_{ji}, \Delta M'_{ji}, \Delta N'_{ji} \end{pmatrix}$	Incremental internal forces and moments at point j due to beam ij, j^{th} body axes
ϕ_i, θ_i, ψ_i	Euler angles from ground axes to body axes (time varying)
$\phi_{ij}, \theta_{ij}, \psi_{ij}$	Euler angles from ith body axes to beam ij axes (constant)
ϕ', θ', ψ'	Euler angles from ground axes to c.g. axes (constant); initial (t=o) attitude of vehicle
$\phi''_i, \theta''_i, \psi''_i$	Euler angles from c.g. axes to ith body axes (constant)

U.S. Government Printing Office: 1974— 636-037/1G Region No. 3-11